VELAMMAL

COLLEGE OF ENGINEERING & TECHNOLOGY, MADURAI – 625 009

(Autonomous)

(Accredited by NAAC with 'A' Grade and by NBA for 6 UG Programmes)

(Approved by AICTE and affiliated to Anna University, Chennai)

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

B.E. ELECTRICAL AND ELECTRONICS ENGINEERING

REGULATIONS – 2021

CHOICE BASED CREDIT SYSTEM (CBCS)

CURRICULUM & SYLLABI

GOLDEN GOALS OF VET

1. Regularity & Punctuality.
2. Nil Failures, High Subject Average & More Centums.
3. Research & Development.
4. Focus in General Knowledge & Depth in the Subject.
5. Communication Skills (Spoken English & Learning more Languages).
6. Extracurricular Activities & Co-Curricular Activities (All-around Development).
7. Good Health and Food Habits.
8. Human Values.

VISION AND MISSION OF THE INSTITUTE

VISION OF VCET

To emerge and sustain as a center of excellence for technical and managerial education upholding social values.

MISSION OF VCET

Our aspirants are

- Imparted with comprehensive, innovative and value – based education.
- Exposed to technical, managerial and soft skill resources with emphasis on research and professionalism.
- Inculcated with the need for a disciplined, happy, married and peaceful life.

VISION AND MISSION OF EEE DEPARTMENT

VISION

To produce quality Electrical Engineers for industry and good citizens for society through excellence in technical education and research.

MISSION

- To empower graduates with sophisticated knowledge and technical skills.
- To explore, create and develop innovations in Electrical Engineering and Technology.
- To provide beneficial service to the rural, state, national and international communities.

VELAMMAL COLLEGE OF ENGINEERING & TECHNOLOGY, MADURAI-625009

(Autonomous)

B.E. ELECTRICAL AND ELECTRONICS ENGINEERING

[CHOICE BASED CREDIT SYSTEM]

REGULATIONS 2021

BATCH 2024 - 2028

CURRICULUM FOR SEMESTERS I TO VIII

SEMESTER – I

S.No.	Course Code	Course Title	Category	L	T	P	C
1.	21IP101	Induction Programme (*Common to all B.E./B.Tech. Programmes*)	MC	-	-	-	0
THEORY							
2.	21EN101	Professional English-I (*Common to all B.E./B.Tech. Programmes*)	HS	3	2	0	4
3.	21MA101	Matrices and Calculus (*Common to all B.E./B.Tech. Programmes*)	BS	3	2	0	4
4.	21PH101	Engineering Physics (*Common to all B.E./B.Tech. Programmes*)	BS	3	0	0	3
5.	21CH101	Engineering Chemistry *(Common to all B.E. / B.Tech..Programmes)*	BS	3	0	0	3
6.	21CS101	Problem Solving and Python Programming (*Common to all B.E./B.Tech. Programmes*)	ES	3	0	0	3
7.	21TA101	Heritage of Tamils/ தமிழர் மரபு	HS	1	0	0	1
PRACTICAL COURSES							
8.	21CS102	Problem Solving and Python Programming Laboratory (*Common to all B.E./B.Tech. Programmes*)	ES	0	0	4	2
9.	21PC101	Physics and Chemistry Laboratory *(Common to all B.E. / B.Tech.Programmes)*	BS	0	0	4	2
Total Credits							**22**

SEMESTER – II

S.No.	Course Code	Course Title	Category	L	T	P	C
THEORY							
1.	21EN102	English –II *(Common to all B.E./B.Tech. Programmes)*	HS	3	0	0	3
2.	21MA102	Vector calculus and Complex Variables (*Common to B.E. CIVIL Engg.,EEE&MECH Engg.*)	BS	3	2	0	4
3.	21PH105	Physics for Electrical Engineering	BS	3	0	0	3
4.	21ME101	Engineering Graphics *(Common to all B.E./B.Tech. Programmes)*	ES	2	0	2	3
5.	21EE101	Electric Circuit Analysis	PC	3	2	0	4
6.	21CH103	Environmental Science *(Common to all B.E./B.Tech.Programmes)*	BS	2	0	0	2
7.	21MC101	Basic Civil and Mechanical Engineering	ES	3	0	0	3
8.	21TA102	Tamils and Technology/ தமிழரும் தொழில்நுட்பமும்	HS	1	0	0	1
PRACTICAL COURSES							
8.	21EM101	Engineering Practices Laboratory *(Common to all B.E./B.Tech. Programmes)*	ES	0	0	4	2
9.	21EE102	Electric Circuits Laboratory	PC	0	0	4	2
Total Credits							**27**

SEMESTER – III

S.No.	Course Code	Course Title	Category	L	T	P	C
THEORY							
1.	21MA202	Transform Techniques and its Applications	BS	3	2	0	4
2.	21EE201	Field Theory	PC	3	2	0	4
3.	21EE202	DC Machines and Transformers	PC	3	0	0	3
4.	21EE203	Transmission and Distribution	PC	3	0	0	3
5.	21EE204	Electronic Devices and Circuits	PC	3	0	0	3
6.	21EE205	Digital Logic Circuits	PC	3	0	0	3
PRACTICAL COURSES							
7.	21EE206	DC Machines and Transformers Laboratory	PC	0	0	4	2
8.	21EE207	Electronic Devices and Digital Laboratory	PC	0	0	4	2
Total Credits							**24**

SEMESTER – IV

S.No.	Course Code	Course Title	Category	L	T	P	C
THEORY							
1.	21MA207	Statistics and Numerical Methods	BS	3	2	0	4
2.	21EE208	Measurements and Instrumentation	PC	3	0	0	3
3.	21EE209	Induction and Synchronous Machines	PC	3	0	0	3
4.	21EE210	Control Systems	PC	3	2	0	4
5.	21EE211	Integrated Circuits	PC	3	0	0	3
THEORY WITH PRACTICAL COURSE							
6.	21EE212	Microprocessors, Microcontrollers and Interfacing	PC	3	0	2	4
PRACTICALCOURSES							
7.	21EE213	Induction and Synchronous Machines Laboratory	PC	0	0	4	2
8.	21EE214	Integrated Circuits and Instrumentation Laboratory	PC	0	0	4	2
Total Credits							**25**

SEMESTER –V

S.No.	Course Code	Course Title	Category	L	T	P	C
THEORY							
1.	21EE301	Power System Analysis	PC	3	0	0	3
2.	21EE302	Power Electronics	PC	3	0	0	3
3.	21EE303	Digital Signal Processing	PC	3	0	0	3
4.	21PEEXX	Professional Elective – I	PE	3	0	0	3
5.	21PEEXX	Professional Elective – II	PE	3	0	0	3
6.	21MCC01	Constitution of India	MC	2	0	0	0
7.	21EE01	Internship[#]	EE	0	0	0	1
THEORY WITH PRACTICAL COURSES							
8.	21EE304	Embedded Systems	PC	2	0	2	3
9.	21CS308	C and Data Structures	ES	2	0	2	3
PRACTICAL COURSES							
10.	21EE305	Power Electronics Laboratory	PC	0	0	4	2
11.	21EN301	Professional Communication Laboratory *(Common to all B.E./B.Tech. Programmes)*	HS	0	0	2	1
Total Credits							**25**

SEMESTER – VI

S.No.	Course Code	Course Title	Category	L	T	P	C
THEORY							
1.	21EE306	Protection and Switchgear	PC	3	0	0	3
2.	21PEEXX	Professional Elective – III	PE	3	0	0	3
3.	21PEEXX	Professional Elective – IV	PE	3	0	0	3
4.	21XXXXX	Open Elective-I	OE	3	0	0	3
5.	21XXXXX	Open Elective-II	OE	3	0	0	3
6.	21MCC02	Essence of Indian Traditional Knowledge	MC	2	0	0	0
7.	21OCEEXX	One Credit Course	EE	0	0	2	1
THEORY WITH PRACTICAL COURSE							
8.	21EE307	Renewable Energy Systems	PC	2	0	2	3
PRACTICAL COURSE							
9.	21EE308	Control Systems and Electrical Drives Laboratory	PC	0	0	4	2
Total Credits							**21**

SEMESTER – VII

S.No.	Course Code	Course Title	Category	L	T	P	C
THEORY							
1.	21EE401	Power System Operation and Control	PC	3	0	0	3
2.	21XXXXX	Open Elective-III	OE	3	0	0	3
3.	21XXXXX	Open Elective-IV	OE	3	0	0	3
PRACTICAL COURSES							
4.	21EE402	Power System Laboratory	PC	0	0	4	2
5.	21EE403	Project Work I	EE	0	0	4	2
Total Credits							**13**

SEMESTER – VIII

S.No.	Course Code	Course Title	Category	L	T	P	C
THEORY							
1.	21PEEXX	Professional Elective – V	PE	3	0	0	3
2.	21PEEXX	Professional Elective – VI	PE	3	0	0	3
PRACTICAL COURSE							
3.	21EE404	Project Work II	EE	0	0	20	10
Total Credits							**16**

 # Industrial training for a period of minimum 2 weeks during the summer / winter vacation.

TOTAL CREDTIS: 173

SEMESTERWISE CREDIT DISTRIBUTION

	I	II	III	IV	V	VI	VII	VIII	Total Credits
HS	5	4	-	-	1	-	-	-	**10**
BS	12	9	4	4	-	-	-	-	**29**
ES	5	8	-	-	3	-	-	-	**16**
PC	-	6	20	21	14	8	5	-	**74**
PE	-	-	-	-	6	6	-	6	**18**
OE	-	-	-	-	-	6	6	-	**12**
EE	-	-	-	-	1	1	2	10	**14**
MC	✓	-	-	-	✓	✓	-	-	**-**
Total	22	27	24	25	25	21	13	16	**173**

S.No.	Topic
1	Humanities and Social Sciences including Management (HS)
2	Basic Sciences (BS)
3	Engineering Sciences including workshop, drawing, basics of electrical/mechanical/computer etc. (ES)
4	Professional Core Courses (PC)
5	Professional Elective : Courses relevant to chosen specialization/ branch (PE)
6	Open Electives : Courses from other technical and/or emerging courses (OE)
7	Project work, Seminar and Internship in Industry –Employability Enhancement Courses (EE)
8	Mandatory Course (MC)
9	One Credit Courses (OC)

PROFESSIONAL ELECTIVE COURSES: VERTICALS

VERTICAL I: POWER ENGINEERING

S.No.	Course Code	Course Title	Category	L	T	P	C
1.	21PEE01	Energy Utilization & Conservation	PE	3	0	0	3
2.	21PEE02	Smart Grid	PE	3	0	0	3
3.	21PEE03	Power Quality	PE	3	0	0	3
4.	21PEE04	Restructured Power Systems	PE	3	0	0	3
5.	21PEE05	Power System Transients	PE	3	0	0	3
6.	21PEE06	Distributed Generation and Micro Grid	PE	3	0	0	3
7.	21PEE07	Energy Management and Auditing	PE	3	0	0	3
8.	21PEE08	Power System Dynamics	PE	3	0	0	3

VERTICAL II: POWER CONVERTERS AND DRIVES

S.No	Course Code	Course Title	Category	L	T	P	C
1.	21PEE09	Modern power converters	PE	3	0	0	3
2.	21PEE 10	Switched Mode Power Converters	PE	3	0	0	3
3.	21PEE11	Power Electronics for Renewable Energy Systems	PE	3	0	0	3
4.	21PEE12	Special Electrical Machines	PE	3	0	0	3
5.	21PEE13	Solid State Drives and Control	PE	3	0	0	3
6.	21PEE14	Digital Control of Electrical drives	PE	3	0	0	3
7.	21PEE15	Wind Energy Conversion System	PE	3	0	0	3
8.	21PEE16	Flexible AC Transmission System	PE	3	0	0	3

VERTICAL III: EMBEDDED SYSTEM ENGINEERING

S.No	Course Code	Course Title	Category	L	T	P	C
1.	21PEE17	Microcontroller based System Design	PE	3	0	0	3
2.	21PEE18	Real Time Operating systems	PE	3	0	0	3
3.	21PEE19	Pervasive devices and Technology	PE	3	0	0	3
4.	21PEE20	Embedded Linux for IoT	PE	3	0	0	3
5.	21PEE21	Embedded Automotive System	PE	3	0	0	3
6.	21PEE22	Internet of Things in Medicine	PE	3	0	0	3
7.	21PEE23	Sensors & Transducers	PE	3	0	0	3

VERTICAL IV: ELECTRIC VEHICLE TECHNOLOGY

S.No	Course Code	Course Title	Category	L	T	P	C
1.	21PEE24	Electric Vehicle Architecture	PE	3	0	0	3
2.	21PEE25	Electric Vehicle Design, Mechanics and Control	PE	3	0	0	3
3.	21PEE26	Electric Hybrid Vehicles	PE	3	0	0	3
4.	21PEE27	Motor and Power Converters for Electric Vehicles	PE	3	0	0	3
5.	21PEE28	Electric Vehicle Charging System	PE	3	0	0	3
6.	21PEE29	Testing of Electric Vehicles	PE	3	0	0	3
7.	21PEE30	Renewable Energy Engineering	PE	3	0	0	3

VERTICAL V: MODERN CONTROL TECHNOLOGIES

S.No.	Course Code	Course Title	Category	L	T	P	C
1.	21PEE31	Non Linear Control System	PE	3	0	0	3
2.	21PEE32	Logic and Distributed Control System	PE	3	0	0	3
3.	21PEE33	Process Modeling and Simulation	PE	3	0	0	3
4.	21PEE34	Computer Control of Processes	PE	3	0	0	3
5.	21PEE35	System Modelling and Identification	PE	3	0	0	3
6.	21PEE36	Process Control	PE	3	0	0	3
7.	21PEE37	Robotics and Control	PE	3	0	0	3

VERTICAL VI: INDUSTRIAL SYSTEMS

S.No.	Course Code	Course Title	Category	L	T	P	C
1.	21PEE38	Nanomaterial for energy harvesting applications	PE	3	0	0	3
2.	21PEE39	Energy Storage Systems	PE	3	0	0	3
3.	21PEE40	Industrial instrumentation	PE	3	0	0	3
4.	21PEE41	Industrial Electrical and Electronics Engineering	PE	3	0	0	3
5.	21PEE42	Analytical Instrumentation	PE	3	0	0	3
6.	21PEE43	Soft Computing Techniques and Applications	PE	3	0	0	3
7.	21PEE44	Design of Electrical Installations	PE	3	0	0	3
8.	21PEE45	High Voltage Engineering	PE	3	0	0	3

ONE CREDIT COURSES

S.No.	Course Code	Course Title	Category	L	T	P	C
1.	21OCEEXX	Softwares for Electrical Engineering	OC	0	0	2	1
2.	21OCEEXX	ANN applications to Electrical Engineering	OC	0	0	2	1
3.	21OCEEXX	Solar power Engineering	OC	0	0	2	1
4.	21OCEEXX	Testing and Calibration System	OC	0	0	2	1
5.	21OCEEXX	Hybrid Energy Systems	OC	0	0	2	1
6.	21OCEEXX	Design Thinking	OC	1	0	0	1

SEMESTER-I

	INDUCTION PROGRAMME	L	T	P	C
21IP101	(Common to all B.E./B.Tech. Programmes)	**0**	**0**	**0**	**0**

This is a mandatory 2 week programme to be conducted as soon as the students enter the institution. Normal classes start only after the induction program is over.

The induction programme has been introduced by AICTE with the following objective:

"Engineering colleges were established to train graduates well in the branch/department of admission, have a holistic outlook, and have a desire to work for national needs and beyond. The graduating student must have knowledge and skills in the area of his/her study. However, he/she must also have broad understanding of society and relationships. Character needs to be nurtured as an essential quality by which he/she would understand and fulfil his/her responsibility as an engineer, as a citizen and as a human being. Besides the above, several meta-skills and underlying values are needed."

"One will have to work closely with the newly joined students in making them feel comfortable, allow them to explore their academic interests and activities, reduce competition and make them work for excellence, promote bonding within them, build relations between teachers and students, give a broader view of life, and build character. "

The following are the activities under the induction program in which the student would be fully engaged throughout the day for the entire duration of the program.

(i) Physical Activity

This would involve a daily routine of physical activity with games and sports, yoga, gardening, etc.

(ii) Creative Arts

Every student would choose one skill related to the arts whether visual arts or performing arts. Examples are painting, sculpture, pottery, music, dance etc. The student would pursue it every day for the duration of the program. These would allow for creative expression. It would develop a sense of aesthetics and also enhance creativity which would, hopefully, grow into engineering design later.

(iii) Universal Human Values

This is the anchoring activity of the Induction Programme. It gets the student to explore oneself and allows one to experience the joy of learning, stand up to peer pressure, take decisions with courage, be aware of relationships with colleagues and supporting stay in the hostel and department, be sensitive to others, etc. A module in Universal Human Values provides the base. Methodology of teaching this content is extremely important. It must not be through do's and dont's, but get students to explore and think by engaging them in a dialogue. It is best taught through group discussions and real life activities rather than lecturing.

Discussions would be conducted in small groups of about 20 students with a faculty mentor each. It would be effective that the faculty mentor assigned is also the faculty advisor for the student for the full duration of the UG programme.

(iv) Literary Activity

Literary activity would encompass reading, writing and possibly, debating, enacting a play etc.

(v) Proficiency Modules

This would address some lacunas that students might have, for example, English, computer familiarity etc.

(vi) Lectures by Eminent People

Motivational lectures by eminent people from all walks of life should be arranged to give the students exposure to people who are socially active or in public life.

(vii) Visits to Local Area

A couple of visits to the landmarks of the city, or a hospital or orphanage could be organized. This would familiarize them with the area as well as expose them to the under privileged.

(viii) Familiarization to Dept./Branch & Innovations

They should be told about what getting into a branch or department means what role it plays in society, through its technology. They should also be shown the laboratories, workshops & other facilities.

(ix) Department Specific Activities

About a week can be spent in introducing activities (games, quizzes, social interactions, small experiments, design thinking etc.) that are relevant to the particular branch of Engineering/Technology/Architecture that can serve as a motivation and kindle interest in building things (become a maker) in that particular field. This can be conducted in the form of a workshop. For example, CSE and IT students may be introduced to activities that kindle computational thinking, and get them to build simple games. ECE students may be introduced to building simple circuits as an extension of their knowledge in Science, and so on. Students may be asked to build stuff using their knowledge of science.

Induction Programme is totally an activity based programme and **therefore there shall be no tests / assessments** during this programme.

REFERENCE:

Guide to Induction program from AICTE

21EN101	**PROFESSIONAL ENGLISH-1** (Common to all B.E./B.Tech. Programmes)	**L**	**T**	**P**	**C**
		3	**2**	**0**	**4**

COURSE OBJECTIVES:

- To develop learners skills in listening and responding effectively
- To apply basic grammar for better communication
- To employ reading passages for understanding vocabulary
- To construct logical sentences and participate in pair presentation, extempore
- To organize ideas for various compositions in writing

UNIT I	INTRODUCTION TO FUNDAMENTALS OF COMMUNICATION	15
Listening – Listening for general information - Specific details - Conversation: Introduction to classmates - Audio / video (formal & informal); Telephone conversation; Listening to voicemail & messages; Listening and filling a form; **Speaking -** Self Introduction; Introducing a friend; Conversation - Politeness strategies; Telephone conversation; Leave a voicemail; Leave a message with another person; asking for information to fill details in a form; **Reading -** Reading brochures (technical context), telephone messages / social media messages relevant to technical contexts and emails; **Writing -** Writing emails / letters introducing oneself; **Grammar -** Present Tense (simple, continuous); Question types: Wh/ Yes or No/ and Tags **Vocabulary -** Synonyms; One word substitution; Abbreviations & Acronyms (as used in technical contexts).		
UNIT II	**NARRATION AND SUMMATION**	**15**
Listening - Listening to podcast, anecdotes / stories / event narration; documentaries and interviews with celebrities; **Speaking** - Narrating personal experiences / events; Interviewing a celebrity; Reporting / and summarizing of documentaries / podcasts/ interviews; **Reading** - Reading biographies, travelogues, newspaper reports, Excerpts from literature, and travel & technical blogs; **Writing** - Guided writing - Paragraph writing Short Report on an event (field trip etc.); **Grammar** - Past tense (Simple, continuous); Subject-Verb Agreement; and Prepositions; **Vocabulary** - Word forms (prefixes& suffixes); Synonyms and Antonyms. Phrasal verbs.		
UNIT III	**DESCRIPTION OF A PROCESS / PRODUCT**	**15**
Listening - Listen to a product and process descriptions; a classroom lecture; and advertisements about a products; **Speaking** - Picture description; Giving instruction to use the product; Presenting a product; and Summarizing a lecture; **Reading** - Reading advertisements, gadget reviews; user manuals; **Writing** - Writing definitions; instructions; and Product /Process description; **Grammar** - Imperatives; Adjectives; Degrees of comparison; Present & Past Perfect, Present and past perfect continuous tenses; **Vocabulary** - Compound Nouns, Homonyms; and Homophones, discourse markers (connectives & sequence words)		
UNIT IV	**CLASSIFICATION AND RECOMMENDATIONS**	**15**
Listening - Listening to TED Talks; Scientific lectures; and educational videos; **Speaking** – Small Talk; Mini presentations and making recommendations; **Reading** - Newspaper articles; Journal reports - Non Verbal Communication (tables, pie charts etc,) **Writing** - Note-making / Note-taking (*Study skills to be taught, not tested); Writing recommendations; Transferring information from non verbal (chart, graph etc, to verbal mode) **Grammar** - Articles; Pronouns - Possessive & Relative pronouns; **Vocabulary** - Collocations; Fixed / Semi fixed expressions		
UNIT V	**EXPRESSIONS**	**15**
Listening - Listening to debates/ discussions; different viewpoints on an issue; and panel discussions; **Speaking** - Group discussions, Debates, and Expressing opinions through Simulations & Role-play; **Reading** - Reading editorials; and Opinion Blogs; **Writing** - Essay Writing (Descriptive or narrative); **Grammar** - Future Tenses, Punctuation; Negation (Statements & Questions); and Simple, Compound & Complex Sentences; **Vocabulary** - Cause & Effect Expressions - Content vs. Function words.		
		TOTAL: 75 PERIODS
COURSE OUTCOMES: At the end of the course, learners will be able to:		

CO1: Listen and comprehend complex academic texts
CO2: Read and infer the denotative and connotative meanings of technical texts
CO3: Write definitions, descriptions, narrations and essays on various topics
CO4: Speak fluently and accurately in formal and informal communicative contexts
CO5: Express their opinions effectively in both oral and written medium of communication

TEXT BOOKS:

1. Dr. Veena Selvam, Dr. Sujatha Priyadarshini, Dr. Deepa Mary Francis, Dr. KN. Shoba, and Dr. Lourdes Joevani, Department of English, Anna University. English for Science & Technology. Cambridge University Press, 2021
2. Board of Editors, Department of English, Anna University. English for Engineers & Technologists. Orient Blackswan Private Ltd, 2020.
3. Board of Editors, Department of English, Anna University. Using English Orient Blackswan Private Ltd, 2017

REFERENCES:

1. Meenakshi Raman & Sangeeta Sharma. Technical Communication – Principles And Practices Oxford University Press, New Delhi, 2016
2. Lakshminarayanan K.R. A Course Book On Technical English. SciTech Publications (India) Pvt. Ltd., 2012
3. Ayesha Viswamohan. English For Technical Communication (With CD). McGraw Hill Education, ISBN: 0070264244. 2008.
4. Kulbhusan Kumar, RS Salaria, Effective Communication Skill. Khanna Publishing House, First Edition, 2018.
5. Dr.V.Chellammal. Learning to Communicate. Allied Publishing House, New Delhi, 2003.

21MA101	MATRICES AND CALCULUS (Common to all B.E./B.Tech. Programmes)	L	T	P	C
		3	2	0	4

COURSE OBJECTIVES:

- To develop the use of matrix algebra techniques that is needed by engineers for practical applications.
- To explain the students about differential calculus.
- To demonstrate the functions of several variables technique to solve problems in many engineering branches.
- To demonstrate the various techniques of integration.
- To prepare the student to use mathematical tools in evaluating multiple integrals and their applications.

UNIT I	MATRICES	12

Eigenvalues and Eigenvectors of a real matrix – Characteristic equation – Properties of Eigenvalues and Eigenvectors – Cayley - Hamilton theorem – Diagonalization of matrices by orthogonal transformation – Reduction of a quadratic form to canonical form by orthogonal transformation – Nature of quadratic forms – Applications: Stretching of an elastic membrane.

UNIT II	DIFFERENTIAL CALCULUS	12

Representation of functions - Limit of a function - Continuity - Derivatives - Differentiation rules (sum, product, quotient, chain rules) - Implicit differentiation - Logarithmic differentiation - Applications : Maxima and Minima of functions of one variable.

UNIT III	FUNCTIONS OF SEVERAL VARIABLES	12
Partial differentiation – Homogeneous functions and Euler's theorem – Total derivative – Change of variables – Jacobians – Partial differentiation of implicit functions – Taylor's series for functions of two variables – Applications : Maxima and minima of functions of two variables and Lagrange's method of undetermined multipliers.		
UNIT IV	**INTEGRAL CALCULUS**	**12**
Definite and Indefinite integrals - Substitution rule - Techniques of Integration: Integration by parts, Trigonometric integrals, Trigonometric substitutions, Integration of rational functions by partial fraction, Integration of irrational functions - Improper integrals - Applications: Hydrostatic force and pressure, moments and centres of mass.		
UNIT V	**MULTIPLE INTEGRALS**	**12**
Double integrals – Change of order of integration – Double integrals in polar coordinates – Area enclosed by plane curves – Triple integrals – Volume of solids – Change of variables in double and triple integrals – Applications: Moments and centres of mass, moment of inertia.		
		TOTAL : 60 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to

CO1: Use the matrix algebra methods for solving engineering problems.
CO2: Apply differential calculus tools in solving various application problems.
CO3: Make use of differential calculus ideas on several variable functions.
CO4: Identify suitable methods of integration in solving practical problems.
CO5**:** Solve practical problems of areas, volumes using multiple integrals.

TEXT BOOKS:

1. Kreyszig.E, "Advanced Engineering Mathematics", 10th Edition, John Wiley and Sons, New Delhi, 2016.
2. Grewal.B.S. "Higher Engineering Mathematics", 44th Edition, Khanna Publishers, New Delhi, 2018.
3. James Stewart, "Calculus: Early Transcendentals", 8th Edition, Cengage Learning, New Delhi, 2015.

REFERENCES:

1. Bali. N., Goyal. M. and Watkins. C., "Advanced Engineering Mathematics", 7th Edition, Firewall Media (An imprint of Lakshmi Publications Pvt., Ltd.,), New Delhi, 2009.
2. Jain. R.K. and Iyengar. S.R.K., "Advanced Engineering Mathematics", 5th Edition, Narosa Publications, New Delhi, 2016.
3. Ramana. B.V., "Higher Engineering Mathematics", 6th Edition, McGraw Hill Education Pvt. Ltd, New Delhi, 2010.
4. Thomas. G. B., Hass. J and Weir. M.D, "Thomas Calculus", 14th Edition, Pearson India, 2018.

21PH101	ENGINEERING PHYSICS (Common to all B.E./B.Tech. Programmes)	L 3	T 0	P 0	C 3

OBJECTIVES:

- To illustrate the students effectively to achieve an understanding of mechanics.
- To infer the students to gain knowledge of electromagnetic waves and its applications.
- To explain the basics of oscillations, optics and lasers.
- To outline the importance of quantum physics.
- To relate the students towards the applications of quantum mechanics.

UNIT I	MECHANICS	9

Multi-particle dynamics: Center of mass (CM) – CM of continuous bodies – motion of the CM – kinetic energy of system of particles. Rotation of rigid bodies: Rotational kinematics – rotational kinetic energy and moment of inertia - theorems of M .I –moment of inertia of continuous bodies – M.I of a diatomic molecule - torque – rotational dynamics of rigid bodies – conservation of angular momentum – rotational energy state of a rigid diatomic molecule - gyroscope - torsional pendulum– double pendulum –Introduction to nonlinear oscillations.

UNIT II	ELECTROMAGNETIC WAVES	9

The Maxwell's equations - wave equation; Plane electromagnetic waves in vacuum, Conditions on the wave field - properties of electromagnetic waves: speed, amplitude, phase, orientation and waves in matter - polarization - Producing electromagnetic waves - Energy and momentum in EM waves: Intensity, waves from localized sources, momentum and radiation pressure - Cell-phone reception. Reflection and transmission of electromagnetic waves from a non-conducting medium vacuum interface for normal incidence.

UNIT III	OSCILLATIONS, OPTICS AND LASERS	9

Simple harmonic motion - resonance –analogy between electrical and mechanical oscillating systems - waves on a string - standing waves - traveling waves - Energy transfer of a wave – sound waves - Doppler effect. Reflection and refraction of light waves - total internal reflection - interference– Michelson interferometer –Theory of air wedge and experiment. Theory of laser - characteristics - Spontaneous and stimulated emission - Einstein's coefficients - population inversion - Nd-YAG laser, CO2 laser, semiconductor laser –Basic applications of lasers in industry.

UNIT IV	BASIC QUANTUM MECHANICS	9

Photons and light waves - Electrons and matter waves –Compton effect - The Schrodinger equation (Time dependent and time independent forms) - meaning of wave function - Normalization –Free particle - particle in an infinite potential well: 1D,2D and 3D Boxes-Normalization, probabilities and the correspondence principle.

UNIT V	APPLIED QUANTUM MECHANICS	9

The harmonic oscillator(qualitative)- Barrier penetration and quantum tunneling(qualitative)-Tunneling microscope - Resonant diode - Finite potential wells (qualitative)- Bloch's theorem for particles in a periodic potential –Basics of Kronig-Penney model and origin of energy bands.

TOTAL: 45 PERIODS

OUTCOMES: At the end of the course, learners will be able to:

CO1: Explain the importance of mechanics.
CO2: Extend their knowledge in electromagnetic waves.
CO3: Illustrate a strong foundational knowledge in oscillations, optics and lasers.
CO4: Interpret the importance of quantum physics.
CO5: Summarize quantum mechanical principles towards the formation of energy bands.

TEXT BOOKS:

1. D.Kleppner and R.Kolenkow, "An Introduction to Mechanics", First Edition, McGraw Hill Education, 2017.
2. E.M.Purcell and D.J.Morin, "Electricity and Magnetism", Third Edition, Cambridge University Press, 2013.
3. Arthur Beiser, Shobhit Mahajan, S. Rai Choudhury, "Concepts of Modern Physics", Seventh Edition, McGraw-Hill, 2017.

REFERENCES

1. R.Wolfson. "Essential University Physics", Volume 1 & 2. , First Edition (Indian Edition) Pearson Education, 2009.
2. Paul A. Tipler, "Physics" - Volume 1 & 2, First Edition (Indian Edition), CBS Publishers & Distributors, 2004.
3. K.Thyagarajan and A.Ghatak. "Lasers: Fundamentals and Applications", Second Edition, Laxmi Publications, (Indian Edition), 2019.
4. D.Halliday, R. Resnick and J. Walker, "Principles of Physics", 10th Edition (Indian Edition), Wiley, 2015.
5. N.Garcia, A.Damask and S.Schwarz, "Physics for Computer Science Students", First Edition, Springer Verlag, 2012.

21CH101	ENGINEERING CHEMISTRY (Common to all B.E./B.Tech. Programmes)	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To describe water quality parameters and water treatment techniques.
- To discuss basic principles and preparatory methods of nanomaterials.
- To demonstrate the basic concepts and applications of phase rule and composites.
- To identify different types of fuels, their preparation, properties and combustion characteristics.
- To illustrate the operating principles, working processes and applications of energy conversion and storage devices.

UNIT I	WATER AND ITS TREATMENT	9

Water: Sources and impurities, **Water quality parameters:** Definition and significance of- colour, odour, turbidity, pH, hardness, alkalinity, TDS, COD and BOD, fluoride and arsenic. **Municipal water treatment:** primary treatment and disinfection (UV, Ozonation, break-point chlorination)**.Desalination of brackish water**: Reverse Osmosis. **Boiler troubles:** Scale and sludge, Boiler corrosion, Caustic embrittlement, Priming &foaming. **Treatment of boiler feed water**: Internal treatment (phosphate, colloidal, sodium aluminate and calgon conditioning) and External treatment – Ion exchange demineralization and zeolite process.

UNIT II	NANOCHEMISTRY	9
Basics: Distinction between molecules, nanomaterials and bulk materials; **Size-dependent properties** (optical, electrical, mechanical and magnetic); **Types of nanomaterials**: Definition, properties and uses of – nanoparticle, nanocluster, nanorod, nanowire and nanotube. **Preparation of nanomaterials:** sol-gel, solvothermal, laser ablation, chemical vapour deposition, electrochemical deposition and electro spinning. **Applications** of nanomaterials in medicine, agriculture, energy, electronics and catalysis.		
UNIT III	**PHASE RULE AND COMPOSITES**	**9**
Phase rule: Introduction, definition of terms with examples. One component system - water system; Reduced phase rule; Construction of a simple eutectic phase diagram - Thermal analysis; Two component system: lead-silver system - Pattinson process. **Composites: Introduction**: Definition & Need for composites; Constitution: Matrix materials (Polymer matrix, metal matrix and ceramic matrix) and Reinforcement (fiber, particulates, flakes and whiskers). **Properties and applications of**: Metal matrix composites (MMC), Ceramic matrix composites and Polymer matrix composites. **Hybrid composites** - definition and examples.		
UNIT IV	**FUELS AND COMBUSTION**	**9**
Fuels: Introduction: Classification of fuels; **Coal and coke**: Analysis of coal (proximate and ultimate), Carbonization, Manufacture of metallurgical coke (Otto Hoffmann method). **Petroleum and Diesel:** Manufacture of synthetic petrol (Bergius process), Knocking - octane number, diesel oil - cetane number; **Power alcohol and biodiesel.** **Combustion of fuels: Introduction**: Calorific value - higher and lower calorific values, Theoretical calculation of calorific value; **Ignition temperature**: spontaneous ignition temperature, Explosive range; **Flue gas analysis** - ORSAT Method. **CO_2 emission and carbon foot print.**		
UNIT V	**ENERGY SOURCES AND STORAGE DEVICES**	**9**
Stability of nucleus: mass defect (problems), binding energy; Nuclear energy: light water nuclear power plant, breeder reactor. **Solar energy conversion:** Principle, working and applications of solar cells**; Recent developments in solar cell materials. Wind energy; Geothermal energy; Batteries:** Types of batteries, Primary battery - dry cell, Secondary battery - lead acid battery and lithium-ion-battery; **Electric vehicles-working principles; Fuel cells:** H_2-O_2 fuel cell, microbial fuel cell; **Supercapacitors:** Storage principle, types and examples.		
		TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to

CO 1: Infer the quality of water from quality parameter data and propose suitable treatment methodologies to treat water.

CO 2: Describe the basic concepts of nanoscience and nanotechnology in designing the synthesis of nanomaterials for engineering and technology applications.

CO 3: Apply the knowledge of phase rule and composites for material selection requirements.

CO 4: Identify suitable fuels for engineering processes and applications.

CO 5: Demonstrate different forms of energy resources and apply them for suitable applications in energy sectors.

TEXT BOOKS:

1. P.C.Jain and Monica Jain, "Engineering Chemistry", 17th Edition, Dhanpat Rai Publishing Company (P) Ltd, New Delhi, 2018.
2.Sivasankar B., "Engineering Chemistry", Tata McGraw-Hill Publishing Company Ltd, NewDelhi, 2008.
3. S.S. Dara, "A text book of Engineering Chemistry", 12th Edition, S. Chand Publishing, 2018.

REFERENCES:

1. B. S. Murty, P. Shankar, Baldev Raj, B.B. Rath and James Murday, "Text book of nanoscience and nanotechnology", Universities Press-II M Series in Metallurgy and Materials Science, 2018.
2.O.G.Palanna, "Engineering Chemistry" 2nd Edition, McGraw Hill Education (India) Private Limited, 2017.
3. Friedrich Emich, "Engineering Chemistry", Scientific International PVT, LTD, New Delhi, 2014.
4. Shikha Agarwal, "Engineering Chemistry-Fundamentals and Applications", 2nd Edition, Cambridge University Press, Delhi, 2019
5. O.V. Roussak and H.D. Gesser, "Applied Chemistry-A Text Book for Engineers and Technologists", 2nd Edition, Springer Science Business Media, New York, 2013.

21CS101	PROBLEM SOLVING AND PYTHON PROGRAMMING (Common to all B.E./B.Tech. Programmes)	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To describe the basics of algorithmic problem solving.
- To solve problems using Python conditionals and loops.
- To illustrate Python functions and use function calls to solve problems.
- To make use of Python data structures - lists, tuples, and dictionaries to represent complex data.
- To explain input/output with files in Python.

UNIT-I	COMPUTATIONAL THINKING AND PROBLEM SOLVING	9

Fundamentals of Computing – Identification of Computational Problems -Algorithms, building blocks of algorithms (statements, state, control flow, functions), notation (pseudo code, flow chart, programming language), algorithmic problem solving, simple strategies for developing algorithms (iteration, recursion). Illustrative problems: find minimum in a list, insert a card in a list of sorted cards, and guess an integer number in a range, Towers of Hanoi.

UNIT-II	DATA TYPES, EXPRESSIONS, STATEMENTS	9

Python interpreter and interactive mode, debugging; values and types: int, float, boolean, string, and list; variables, expressions, statements, tuple assignment, precedence of operators, comments; Illustrative programs: exchange the values of two variables, circulate the values of n variables, distance between two points.

UNIT-III	CONTROL FLOW, FUNCTIONS, STRINGS	9

Conditionals: Boolean values and operators, conditional (if), alternative (if-else), chained conditional (if-else-if-else); Iteration: state, while, for, break, continue, pass; Fruitful

functions: return values, parameters, local and global scope, function composition, recursion; Strings: string slices, immutability, string functions and methods, string module; Lists as arrays. Illustrative programs: square root, gcd, exponentiation, sum an array of numbers, linear search, binary search.		
UNIT-IV	**LISTS, TUPLES, DICTIONARIES**	**9**
Lists: list operations, list slices, list methods, list loop, mutability, aliasing, cloning lists, list parameters; Tuples: tuple assignment, tuple as return value; Dictionaries: operations and methods; advanced list processing - list comprehension; Illustrative programs: simple sorting, histogram, Students marks statement, Retail bill preparation.		
UNIT-V	**FILES, MODULES, PACKAGES**	**9**
Files and exceptions: text files, reading and writing files, format operator; command line arguments, errors and exceptions, handling exceptions, modules, packages; Illustrative programs: word count, copy file, Voter's age validation, Marks range validation (0-100).		
		TOTAL :45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to

CO1: Make use of design approaches to solve computational problems.

CO2: Develop and execute basic Python programs using expressions and input/output statements.

CO3: Utilize strings, functions and control statements to develop real world problems.

CO4: Construct programs using Python data types like lists, tuples and dictionaries.

CO5: Prepare a Python application by incorporating files and exceptions.

TEXT BOOKS:

1. Allen B. Downey, "Think Python: How to Think like a Computer Scientist", 2nd Edition, O'Reilly Publishers, 2016.

2. Karl Beecher, "Computational Thinking: A Beginner's Guide to Problem Solving and Programming", 1st Edition, BCS Learning & Development Limited, 2017.

3. Martin C. Brown, "Python: The Complete Reference", 4th Edition, Mc- Graw Hill, 2018.

REFERENCES:

1. Paul Deitel and Harvey Deitel, "Python for Programmers", 1st Edition, Pearson Education, 2021.

2. G Venkatesh and Madhavan Mukund, "Computational Thinking: A Primer for Programmers and Data Scientists", 1st Edition, Notion Press, 2021.

3. John V Guttag, "Introduction to Computation and Programming Using Python: With Applications to Computational Modeling and Understanding Data", 3rd Edition, MIT Press, 2021

4. Eric Matthes, "Python Crash Course, A Hands - on Project Based Introduction to Programming", 2nd Edition, No Starch Press, 2019

21TA101	**HERITAGE OF TAMILS / தமிழர்மரபு** *(Common to all B.E./B.Tech. Programmes)*	**L**	**T**	**P**	**C**
		1	**0**	**0**	**1**
UNIT I	**LANGUAGE AND LITERATURE**				**3**
Language Families in India - Dravidian Languages – Tamil as a Classical Language - Classical Literature in Tamil – Secular Nature of Sangam Literature – Distributive Justice in Sangam					

Literature - Management Principles in Thirukural - Tamil Epics and Impact of Buddhism & Jainism in Tamil Land - Bakthi Literature Azhwars and Nayanmars - Forms of minor Poetry - Development of Modern literature in Tamil - Contribution of Bharathiyar and Bharathidhasan.		
UNIT II	**HERITAGE -ROCK ART PAINTINGS TO MODERN ART – SCULPTURE**	**3**
Hero stone to modern sculpture - Bronze icons - Tribes and their handicrafts - Art of temple carmaking - - Massive Terracotta sculptures, Village deities, Thiruvalluvar Statue at Kanyakumari,Making of musical instruments - Mridhangam, Parai, Veenai, Yazh and Nadhaswaram - Role of Temples in Social and Economic Life of Tamils.		
UNIT III	**FOLK AND MARTIAL ARTS**	**3**
Therukoothu, Karagattam, Villu Pattu, Kaniyan Koothu, Oyillattam, Leatherpuppetry, Silambattam, Valari, Tiger dance - Sports and Games of Tamils.		
UNIT IV	**THINAI CONCEPT OF TAMILS**	**3**
Flora and Fauna of Tamils & Aham and Puram Concept from Tholkappiyam and Sangam Literature- Aram Concept of Tamils - Education and Literacy during Sangam Age - Ancient Cities and Ports of Sangam Age - Export and Import during Sangam Age - Overseas Conquest of Cholas.		
UNIT V	**CONTRIBUTION OF TAMILS TO INDIAN NATIONAL MOVEMENT AND INDIAN CULTURE**	**3**
Contribution of Tamils to Indian Freedom Struggle - The Cultural Influence of Tamils over the other parts of India – Self-Respect Movement - Role of Siddha Medicine in Indigenous Systems of Medicine – Inscriptions & Manuscripts – Print History of Tamil Books.		
		TOTAL: 15 PERIODS

TEXT-CUM-REFERENCE BOOKS

1. *தமிழகவரலாறு மக்களும் பண்பாடும்* கே.கே.பிள்ளை (*வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்*)
2. *கணினித்தமிழ்முனைவர் இல. சுந்தரம்.* (*விகடன் பிரசுரம்*).
3. *கீழடி வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம்* (*தொல்லியல் துறை வெளியீடு*)
4. *பொருநை ஆற்றங்கரை நாகரிகம்.* (*தொல்லியல் துறை வெளியீடு*)
5. Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
6. Social Life of the Tamils - The Classical Period (Dr.S.Singaravelu) (Published by: International Institute of Tamil Studies.)
7. Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies.)
9. Keeladi - 'Sangam City C ivilization on the banks of river Vaigai' (Jointly Published by:

Department ofArchaeology& Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)

10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Publishedby: The Author)
11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

21CS102	PROBLEM SOLVING AND PYTHON PROGRAMMING LABORATORY (Common to all B.E./B.Tech. Programmes)	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES:

- To describe the basics of algorithmic problem solving.
- To solve problems using Python conditionals and loops.
- To illustrate Python functions and use function calls to solve problems.
- To make use of Python data structures - lists, tuples, and dictionaries to represent complex data.
- To explain input/output with files in Python.

LIST OF EXPERIMENTS

1. Identification and solving of simple real life or scientific or technical problems, and developing flow charts for the same. (Electricity Billing, Retail shop billing, Sin series, weight of a motorbike, Weight of a steel bar, compute Electrical Current in Three Phase AC Circuit, etc.,)
2. Python programming using simple statements and expressions (exchange the values of two variables, circulate the values of n variables, distance between two points).
3. Scientific problems using Conditionals and Iterative loops. (Number series, Number Patterns, pyramid pattern)
4. Implementing real-time/technical applications using Lists, Tuples. (Items present in a library/Components of a car/ Materials required for construction of a building –operations of list & tuples)
5. Implementing real-time/technical applications using Sets, Dictionaries. (Language, components of an automobile, Elements of a civil structure, etc.,- operations of Sets & Dictionaries)
6. Implementing programs using Functions. (Factorial, largest number in a list, area of shape)
7. Implementing programs using Strings. (reverse, palindrome, character count, replacing characters)
8. Implementing programs using written modules and Python Standard Libraries (pandas, numpy. Matplotlib, scipy)
9. Implementing real-time/technical applications using File handling. (copy from one file to another, word count, longest word)
10. Implementing real-time/technical applications using Exception handling. (divide by zero error,voter's age validity, student mark range validation)

11. Exploring Pygame tool.
12. Developing a game activity using Pygame like bouncing ball, car race etc.,

TOTAL:60 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to

CO1:Develop algorithmic solutions to simple computational Problems

CO2: Illustrate and execute basic Python programs using simple statements.

CO3: Build program for scientific problems using strings, functions and control statements.

CO4: Utilize compound data types lists, tuples and dictionaries for real-time applications.

CO5: Experiment the python packages, files and exceptions for developing software applications

21PC101	PHYSICS AND CHEMISTRY LABORATORY (Common to all B.E./B.Tech. Programmes)	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES:

- To explain the proper use of various kinds of physics laboratory equipment.
- To extend how data can be collected, presented and interpreted in a clear and concise manner
- To infer problem solving skills related to physics principles and interpretation of experimental data.
- To summarize error in experimental measurements and techniques used to minimize such error.
- To translate the student as an active participant in each part of all lab exercises.

LIST OF EXPERIMENTS: PHYSICS LABORATORY (Any 7 Experiments)

1. Torsional pendulum - Determination of rigidity modulus of wire and moment of inertia of regular and irregular objects.
2. Simple harmonic oscillations of cantilever.
3. Non-uniform bending - Determination of Young's modulus
4. Uniform bending – Determination of Young's modulus
5. Laser- Determination of the wave length of the laser using grating
6. Air wedge - Determination of thickness of a thin sheet/wire
7. a) Optical fibre -Determination of Numerical Aperture and acceptance angle
   b) Compact disc- Determination of width of the groove using laser.
8. Acoustic grating- Determination of velocity of ultrasonic waves in liquids.
9. Ultrasonic interferometer – Determination of the velocity of sound and compressibility of liquids
10. Post office box - Determination of Band gap of a semiconductor.
11. Photoelectric effect
12. Michelson Interferometer.
13. Melde's string experiment
14. Experiment with lattice dynamics kit.

TOTAL: 30 PERIODS

OUTCOMES: At the end of the course, learners will be able to:

CO1:.Explain the functioning of various physics laboratory equipment

CO2: Relate the graphical models to analyze laboratory data

CO3: Interpret mathematical models as a medium for quantitative reasoning and describing physical reality.

CO4: Explain Access, process and analyze scientific information.

CO5: Translate students to solve problems individually and collaboratively

REFERENCES :

1. "Physics Laboratory Manual", Department of Physics, Velammal College of Engineering & Technology, Madurai (2021)
2. P. Mani, "Physics Laboratory", Dhanam Publications, 2021.

CHEMISTRY LABORATORY

COURSE OBJECTIVES:

- To inculcate experimental skills to test basic understanding of water quality parameters such as acidity, alkalinity, hardness, DO, chloride and copper.
- To induce the students to familiarize with electro analytical techniques such as pH metry, potentiometry and conductometry in the determination of impurities in aqueous solutions.
- To demonstrate the analysis of metals and alloys.
- To demonstrate the synthesis of nanoparticles.
- To analyze the quality of coal sample using proximate analysis.

List of Experiments (Any 7 experiments)

1. Preparation of Na_2CO_3 as a primary standard and estimation of acidity of a water sample using the primary standard.
2. Determination of types and amount of alkalinity in water sample.
3. Determination of total, temporary & permanent hardness of water by EDTA method.
4. Determination of DO content of water sample by Winkler's method.
5. Determination of chloride content of water sample by Argentometric method.
6. Estimation of copper content of the given solution by Iodometry.
7. Estimation of TDS of a water sample by gravimetry.
8. Determination of strength of given hydrochloric acid using pH meter.
9. Determination of strength of acids in a mixture of acids using conductivity meter.
10. Conductometric titration of barium chloride against sodium sulphate. (precipitation titration)
11. Estimation of iron content of the given solution using potentiometer.
12. Estimation of sodium /potassium present in water using flame photometer.
13. Preparation of nanoparticles (TiO_2/ZnO/CuO) by Sol-Gel method.
14. Estimation of Nickel in steel.
15. Proximate analysis of Coal.

TOTAL: 30 PERIODS

COURSE OUTCOMES : At the end of the course, learners will be able to

CO1: To analyse the quality of water samples with respect to their acidity, alkalinity, hardness and DO.

CO2: To determine the amount of metal ions through volumetric and spectroscopic techniques.

CO3: To analyse and determine the composition of alloys. CO4: To learn simple method of synthesis of nanoparticles. CO5: To quantitatively analyse the impurities in solution by electro analytical techniques.
Text Book: J. Mendham, R. C. Denney, J.D. Barnes, M. Thomas and B. Sivasankar, "Vogel's Textbook of Quantitative Chemical Analysis" 2009.

SEMESTER-II

21EN102	ENGLISH-II (Common to all B.E./B.Tech. Programmes)	L 3	T 0	P 0	C 3

COURSE OBJECTIVES:

- To develop strategies and skills for enhance learners' ability to read and comprehend engineering and technology texts.
- To foster their ability to write convincing job applications and effective reports.
- To develop their speaking skills to make them confident in technical presentations and participate in group discussions.
- To strengthen their Listening skill which will help them comprehend lectures and talks in their areas of specialization.
- To create awareness about the need for soft skills.

UNIT I	INTRODUCTION TO TECHNICAL ENGLISH	9

Listening - Factual and Academic speeches; **Speaking** - Asking for and Giving Directions; **Reading** - Technical Texts from Newspapers/Websites; **Writing –** Statements, Definitions, Issue Based Writing, Instructions, Checklist, Recommendations; **Vocabulary Development**- Technical Vocabulary; **Grammar** - Error spotting, Compound Words; **Soft Skills** - Leadership Skills.

UNIT II	READING AND STUDY SKILLS	9

Listening - Listening to Longer Technical Talks and Completing Exercises Based on Them; **Speaking** - Describing a General Process; **Reading** - Reading Longer Technical Texts, Identifying the Various Transitions in a Text, Paragraphing; **Writing** - Interpreting Charts, Graphs; **Vocabulary Development** - Vocabulary Used in Formal Letters/Emails and Reports; **Grammar -** Impersonal Passive Voice, Numerical Adjectives; **Soft Skills** – Teamwork.

UNIT III	TECHNICAL WRITING AND GRAMMAR	9

Listening - Listening to Classroom Lectures, Talks on Engineering /Technology; **Speaking** - Introduction to Technical Presentations; **Reading** - Longer Texts both General and Technical, Practice in Speed Reading; **Writing** - Describing a Technical Process; **Vocabulary Development** - Sequence Words, Misspelt Words; **Grammar** - Embedded Sentences ; **Soft Skills** - Decision Making

UNIT IV	JOB APPLICATIONS	9

Listening - Listening to Documentaries and Making Notes; **Speaking** - Mechanics of Presentations; **Reading -** Reading for Detailed Comprehension; **Writing** - Email Etiquette, Job Application, Cover Letter, Resume Preparation(softcopy and hard copy), Analytical Essay

Writing; **Vocabulary Development -** Finding Suitable Synonyms, Paraphrasing; **Grammar** – Clauses, 'If' Conditionals; **Soft Skills** - Time Management.		
UNIT V	**GROUP DISCUSSION AND REPORT WRITING**	**9**
Listening - TED Talks; **Speaking** - Participating in a Group Discussion; **Reading** - Reading and Understanding Technical Articles; **Writing** - Writing Reports, Survey Report, Accident Report, Minutes of a Meeting; **Vocabulary Development** - Verbal Analogies; **Grammar** - Reported Speech; **Soft Skills** - Conflict Resolution.		
	TOTAL: 45 PERIODS	

COURSE OUTCOMES : At the end of the course, learners will be able to

CO1: Read and interpret information in technical texts
CO2: Construct convincing job applications, resume and effective reports
CO3: Organize the technical ideas effectively in spoken and written forms
CO4: Interpret spoken language in lectures and talks
CO5: Demonstrate basic soft skills in life

TEXT BOOKS:

1. Board of Editors, "Fluency in English-A Course book for Undergraduate Engineers and Technologist" Orient Blackswan Pvt Ltd, Hyderabad: 2018
2. Jawahar, Jewelcy & Rathna.P., "Communicative English Workbook" VRB Publishers Pvt Ltd., Chennai, 2018.
3. Board of Editors, Department of English, Anna University, Chennai. Mindscapes-English for Technologists and Engineers. Orient Black Swan Pvt Ltd, Chennai, 2012.

REFERENCES:

1. Verma, Shalini, " Technical Communication for Engineers" Vikas Publishing House Pvt Ltd., New Delhi, 2015
2. Raman, Meenakshi & Sharma, Sangeeta, " Technical Communication English Skills for Engineers" Oxford University Press, 2008.
3. Rizvi, Ashraf.M, "Effective Technical Communication" MC Graw Hill Education Pvt Ltd., New Delhi, 2016.

21MA102	**VECTOR CALCULUS AND COMPLEX VARIABLES (Common to B.E. CIVIL Engg., EEE&MECH Engg.)**	**L**	**T**	**P**	**C**
		3	**2**	**0**	**4**

COURSE OBJECTIVES:

- To explain the students with the concepts of vector calculus, needed for problem solving in all engineering disciplines.
- To choose the effective mathematical methods for finding the solutions of partial differential equations.
- To identify and develop the standard techniques of complex variables.
- To apply with confidence, in application areas such as heat conduction, elasticity, fluid dynamics and flow of electric current.
- To prepare the student to acquire sound knowledge of techniques in solving ordinary differential equations that model engineering problems.

UNIT I	**VECTOR CALCULUS**	**12**
Gradient , Divergence and Curl – Directional derivation – Irrotational and solenoidal vector fields –Vector integration – Greens theorem in a plane , Gauss Divergence		

theorem and Stoke's theorem (excluding proof) – Simple applications involving cubes and rectangular parallelepiped

UNIT II	PARTIAL DIFFERENTIAL EQUATIONS	12

Formation of partial differential equations – Solutions of standard types of first order PDE : f(p, q) = 0, f(z ,p,q)=0, z=px+ qy + f(p,q), f(x, p) = f(y, q) – Lagrange's linear equations – linear partial differential equations of second and higher order with constant coefficients of homogeneous type.

UNIT III	ANALYTIC FUNCTIONS	12

Analytic functions – necessary and sufficient conditions for analyticity-properties – Harmonic conjugates- construction of analytic function – conformal mapping –Mapping by functions- Bilinear transformation $w = c + z\ , az\ , \frac{1}{z}, z^2$.

UNIT IV	COMPLEX INTEGRATION	12

Complex Integration – Cauchy's integral theorem and integral formula (excluding proof)-Taylor series and Laurent's series –Residues – Cauchy's residue Theorem (excluding proof) – Application of Residue theorem to evaluate real integrals around unit circle and semi- circle (excluding poles on the real axis).

UNIT V	ORDINARY DIFFERENTIAL EQUATIONS	12

Linear equations of second order with constant and variable coefficients-Homogeneous equations of Euler type – Equations reducible to homogeneous form –Variation of parameters-Simultaneous first order with constant coefficients.

TOTAL: 60 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to

CO1: Apply the concept of vector calculus which naturally arises in many engineering Problems.
CO2: Solve the Partial Differential Equations by using various techniques.
CO3: Construct an analytic function using the properties of analytic function.
CO4: Apply suitable formula to evaluate the given integral.
CO5: Use a suitable method , solve the given differential equation of first & second order.

TEXT BOOKS:

1. Kreyszig Erwin, "Advanced Engineering Mathematics ", 10th Edition, John Wiley and Sons, New Delhi**,** 2016.
2. James Stewart, " Calculus: Early Transcendentals", 8th Edition, Cengage Learning New Delhi, 2015.
3. Thomas. G. B., Hass. J, and Weir. M.D, "Thomas Calculus", 14th Edition, Pearson Education, 2018.

REFERENCES :

1. B.S.Grewal, " Higher Engineering Mathematics", 43rd Edition, Khanna Publishers, 2015.
2. P. Kandasamy , Thilagavathy and K.Gunavathy, " Engineering Mathematics Vol-II", 3rd Edition, S. Chand Limited, 2015.
3. P. Kandasamy , Thilagavathy and K.Gunavathy, " Engineering Mathematics Vol-III", 3rd Edition, S. Chand Limited, 2015

21PH105	PHYSICS FOR ELECTRICAL ENGINEEIRNG	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To explain the basics of dielectric materials and insulation.
- To illustrate the electrical properties of materials including free electron theory, applications of quantum mechanics and magnetic materials.
- To infer knowledge on physics of semiconductors, determination of charge carriers and device applications.
- To summarize the different optical properties of materials, optical displays and applications.
- To translate the significance of nano structures, quantum confinement to nano device applications.

UNIT I	DIELECTRIC MATERIALS AND INSULATION	9

Matter polarization and relative permittivity: definition - Dipole moment and polarization vector Polarization mechanisms: electronic, ionic, orientation, interfacial and total polarization - Frequency dependence - Local field and Causius-Mossotti equation - Dielectric constant and dielectric loss - Gauss's law and boundary conditions - Dielectric strength, introduction to insulation breakdown in gases, liquids and solids - Capacitor materials - Typical capacitor constructions - Piezo and pyroelectric crystals (qualitative).

UNIT II	ELECTRICAL AND MAGNETIC PROPERTIES OF MATERIALS	9

Classical free electron theory - Expression for electrical conductivity - Thermal conductivity, expression - Quantum free electron theory: tunneling - Degenerate states - Fermi-Dirac statistics - Density of energy states - Electron effective mass - concept of hole. Magnetic materials: dia, para and ferromagnetic effects - Domain theory of ferromagnetism - Hysteresis - Quantum interference devices - GMR devices.

UNIT III	SEMICONDUCTORS AND TRANSPORT PHYSICS	9

Intrinsic Semiconductors – Energy band diagram - Direct and indirect band gap semiconductors - Carrier concentration in intrinsic semiconductors - Extrinsic semiconductors - Carrier concentration in n-type & p-type semiconductors - Variation of carrier concentration with temperature - Carrier transport in Semiconductors: Drift, mobility and diffusion - Hall effect and devices - Ohmic contacts - Schottky diode.

UNIT IV	OPTICAL PROPERTIES OF MATERIALS	9

Classification of optical materials - Optical processes in semiconductors: optical absorption and emission, charge injection and recombination, optical absorption, loss and gain. Optical processes in quantum wells - Optoelectronic devices: light detectors and solar cells - light emitting diode - laser diode - optical processes in organic semiconductor devices - excitonic state - Electro-optics and nonlinear optics: Modulators and switching devices.

UNIT V	NANO DEVICES	9

Density of states for solids - Significance between Fermi energy and volume of the material - Quantum confinement - Quantum structures - Density of states for quantum wells, wires and dots - Band gap of nanomaterials - Tunneling - Single electron phenomena - Single electron Transistor. Conductivity of metallic nanowires - Ballistic transport - Quantum resistance and conductance - Carbon nanotubes: Properties and applications - Spintronic devices and applications - Optics in quantum structures - quantum well laser.

	TOTAL: 45 PERIODS

OUTCOMES: At the end of the course, learners will be able to:

CO1:Explain the basics of dielectric materials and insulation.
CO2:Infer the electrical and magnetic properties of materials and their applications.
CO3:Relate the semiconductor physics and functioning of semiconductor devices.
CO4:Summarize the optical properties of materials and working principles of various optical devices.
CO5:Translate the importance of nanotechnology in nano devices.

TEXT BOOKS:

1. S.O. Kasap, "Principles of Electronic Materials and Devices", 4th Edition (Indian Edition), McGraw Hill Education, 2020.
2. R.F. Pierret, "Semiconductor Device Fundamentals", 1st Edition (Indian Edition) Pearson, 2006.
3. G.W.Hanson. "Fundamentals of Nanoelectronics", 1st Edition (Indian Edition) Pearson Education, 2009.

REFERENCES

1. Laszlo Solymar, Walsh, Donald, Syms and Richard R.A., "Electrical Properties of Materials", Indian Edition, Oxford University Press, 2015.
2. Jasprit Singh, "Semiconductor Optoelectronics: Physics and Technology", First Edition (Indian Edition), McGraw-Hill Education, 2019.
3. Charles Kittel, "Introduction to Solid State Physics", Seventh Edition, (Indian Edition), Wiley, 2019.
4. Mark Fox, "Optical Properties of Solids", Standard Edition, Oxford University Press, 2001.
5. Parag K. Lala, "Quantum Computing: A Beginner's Introduction", First Edition (Indian Edition) , McGraw-Hill Education, 2020.

21ME101	ENGINEERING GRAPHICS (Common to all B.E./B.Tech. Programmes)	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES:

- To sketch the projection of points, lines and planes.
- To sketch the projection of simple solids
- To sketch the projection of sectioned solids and development of lateral surfaces
- To sketch the isometric and perspective views of simple solids.
- To sketch the orthographic projection of various objects freehandly.

UNIT I	PROJECTIONS OF POINTS, LINES AND PLANE SURFACE	9

Importance of graphics in engineering applications – Use of drafting instruments - Lettering and dimensioning.

Introduction to Orthographic projections - Principles -Principal planes-First angle projection. Projection of points located in all quadrants. Projection of straight lines inclined to both the principal planes - Determination of true lengths and true inclinations by rotating line method.

Projection of planes (regular polygonal and circular surfaces) inclined to both the principal planes by rotating object method. (Not for Examination)

UNIT II	PROJECTION OF SOLIDS	9
Projection of simple solids like prisms, pyramids, cylinder, cone and truncated solids when the axis is inclined to one of the principal planes by rotating object method.		
UNIT III	**PROJECTION OF SECTIONED SOLIDS AND DEVELOPMENT OF SURFACES**	**9**
Sectioning of above solids in simple vertical position when the cutting plane is inclined to the one of the principal planes and perpendicular to the other – obtaining true shape of section. Development of lateral surfaces of simple and sectioned solids – Prisms, pyramids cylinders and cones.		
UNIT IV	**ISOMETRIC AND PERSPECTIVE PROJECTIONS**	**9**
Principles of isometric projection – isometric scale –Isometric projections of simple solids and truncated solids - Prisms, pyramids, cylinders, cones- Perspective projection of simple solids- Prisms, pyramids and cylinders by visual ray method .		
UNIT V	**FREEHAND SKETCHING**	**9**
Visualization concepts and Free Hand sketching: Visualization principles –Representation of Three Dimensional objects – Layout of views- Freehand sketching of multiple views from pictorial views of objects. Introduction to drafting packages and demonstration. (Not for examination).		
TOTAL: 45 PERIODS		

COURSE OUTCOMES:

At the end of the course, learners will be able to

CO1: Construct the orthographic projections of points, straight lines and plane surfaces.

CO2: Sketch the orthographic projections of simple solids

CO3: Sketch the orthographic projections of sectional solids and lateral surfaces of the solids.

CO4: Construct the isometric projections and perspective projections of simple solids.

CO5: Sketch the orthographic projection of objects using freehand.

TEXT BOOKS:

1. Natarajan K.V., "A text book of Engineering Graphics", 31st Edition, Dhanalakshmi Publishers, Chennai, 2018.
2. Venugopal K. and Prabhu Raja V., "Engineering Graphics", 15th Edition, New Age International (P) Limited, 2018.
3. Bhatt N.D. and Panchal V.M., "Engineering Drawing", 53rd Edition, Charotar Publishing House, 2014.

REFERENCES:

1. Basant Agarwal and Agarwal C.M., "Engineering Drawing", 2nd Edition, Tata McGraw Hill Publishing Company Limited, 2013.
2. Parthasarathy N. S. and Vela Murali, "Engineering Graphics", 2nd Edition, Oxford University, Press, New Delhi, 2015.
3. Shah M.B., and Rana B.C., "Engineering Drawing", 2nd Edition, Pearson, 2009.

21EE101	ELECTRIC CIRCUIT ANALYSIS	L	T	P	C
		3	2	0	4

COURSE OBJECTIVES:

- To explain the electric circuits and its analysis.
- To interpret circuit equations using network theorems.
- To illustrate phenomenon of resonance in coupled circuits.
- To outline the transient response of circuits.
- To summarize the phasor diagrams and analysis of three phase circuits.

UNIT I	BASIC CIRCUITS ANALYSIS	15

Resistive elements - Ohm's Law- Resistors in series and parallel circuits – Kirchhoff's laws – Mesh current and node voltage - Method of analysis for DC and AC circuits - Phasor Diagram – Power, Power Factor and Energy.

UNIT II	NETWORK REDUCTION AND THEOREMS FOR DC AND AC CIRCUITS	15

Network reduction: voltage and current division, source transformation – Star delta conversion. Thevenin's and Norton's Theorem – Superposition Theorem – Maximum power transfer theorem – Reciprocity Theorem –Millman's theorem.

UNIT III	TRANSIENT RESPONSE ANALYSIS	15

Transient response of RL, RC and RLC Circuits using Laplace transform for DC input and A.C. sinusoidal input.

UNIT IV	THREE PHASE CIRCUITS	15

A.C. circuits - Advantages of three phase system - Generation of three phase voltages - Phase sequence - Average and RMS value - Analysis of three phase 3-wire and 4-wire circuits with star and delta connected loads, balanced and unbalanced – Phasor diagram of voltages and currents – power measurement in three phase circuits.

UNIT V	RESONANCE AND COUPLED CIRCUITS	15

Series and parallel resonance –Their frequency response – Quality factor and Bandwidth - Self and mutual inductance – Coefficient of coupling – Tuned circuits – Analysis of single tuned and Double tuned coupled circuits.

TOTAL: 75 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to

CO1: Analyze electrical circuits using electric circuit laws
CO2: Choose circuit theorems for solving a given electric circuits.
CO3: Examine steady state and transient response on electric circuit.
CO4: Experiment with resonant circuits and coupled circuits.
CO5: Solve three phase star and delta connected systems with balanced and unbalanced loads.

TEXT BOOKS:

1. Charles K. Alexander, Mathew N.O. Sadiku, "Fundamentals of Electric Circuits", 5th Edition, McGraw-Hill, 2013.
2. William H. HaytJr, Jack E. Kemmerly and Steven M. Durbin, "Engineering CircuitsAnalysis", 9th Edition, McGraw-Hill publishers, New Delhi, 2020.
3. Sudhakar A and Shyam Mohan S.P., "Circuits and Network Analysis and Synthesis", 5thEdition, McGraw-Hill, 2017.
4. NageswaraRaoT., "Circuit Theory",5thEdition, A.R.Publication, 2017.

REFERENCES

1. Chakrabarti A, "Circuits Theory (Analysis and synthesis), 7thEdition, DhanpatRai& Sons, NewDelhi ,2018.
2. Allan H. Robbins, Wilhelm C. Miller, "Circuit Analysis Theory and Practice", 5thEdition, CengageLearning India, 2013.
3. Mahadevan, K., Chitra, C., "Electric Circuits Analysis", 2nd Edition, Prentice-Hall of India Pvt Ltd., New Delhi, 2018.
4. Jegatheesan, R., "Analysis of Electric Circuits," 6thEdition, McGraw-Hill, 2018.
5. James W. Nilsson, Susan Riedel, "Electric Circuits", 11th Edition, Pearson,2018.

21CH103	ENVIRONMENTAL SCIENCE (Common to all B.E / B.Tech. Programmes)	L	T	P	C
		2	0	0	2

COURSE OBJECTIVES:

- To describe the structure and function of an ecosystem and biodiversity
- To interpret the environmental impacts of natural resources.
- To demonstrate causes, effects and control measures of different types of pollution.
- To manipulate the importance of disaster management, environmental ethics and values.
- To dramatize the important social issues and sustainable practices.

UNIT-I	ENVIRONMENT, ECOSYSTEM AND BIODIVERSITY	6

Multidisciplinary nature of environmental studies - ecosystem- general structure and function of an ecosystem- ecological succession-biodiversity-types-values of biodiversity- endangered and endemic species-red data book- hot spots of biodiversity-criteria- hot spots in India-threats to biodiversity(man-animal conflicts, habitat loss, poaching)-case studies-conservation of biodiversity- in-situ and ex-situ conservation.

UNIT-II	NATURAL RESOURCES AND ITS ENVIRONMENTAL IMPACTS	6

Natural resources-forest resource-ecological functions – causes, effects and control measures of deforestation-water resource-sources-conflict over water-dams benefits and problems-food resource-overgrazing- impacts of over grazing- impacts of modern agriculture-energy resource-environmental impacts of wind mills and solar panels- role of an individual in conservation of natural resources.

UNIT III	ENVIRONMENTAL POLLUTION AND CONTROL	6

Air pollution-causes, effects and control methods - water pollution- causes, effects-waste water treatment-soil pollution-causes, effects-solid waste management–e-waste- causes, effects and management-Pollution control acts-air(prevention and control of pollution) act,1981-water(prevention and control of pollution) act,1974- wildlife (protection) act,1972 - e-waste management rules,2016-case studies - role of an individual in control of pollution.

UNIT IV	DISASTER MANAGEMENT AND ENVIRONMENTAL ETHICS	6

Disaster management-causes, effects and management of- flood, landslide, earthquake and tsunami-case studies- environmental ethics- value education-traditional value systems in India-water conservation-rain water harvesting-watershed management.

UNIT V	SOCIAL ISSUES AND SUSTAINABLE PRACTICES	6

Unsustainable development- social issues-climate change-causes, effects and control measures-global warming-causes, effects and control measures-Acid rain-causes, effects and control

measures-ozone layer depletion-causes, effects and control measures-nuclear accident and holocausts-EIA-Sustainable development-goals-target- green buildings- ISO 14000 series.
TOTAL: 30 PERIODS
COURSE OUTCOMES : At the end of the course, learners will be able to CO1: Explain the concept, structure and function of an ecosystem and biodiversity. CO2: Demonstrate the environmental impacts of natural resources. CO3: Illustrate the suitable management method for pollution control. CO4: Relate the proper way of managing disaster with environmental ethics. CO5: Apply social issues and adopt suitable sustainable practices.
TEXT BOOKS: 1.Kaushik, A &Kaushik. C.P, "Environmental Science and Engineering", 6th Edition, New Age International, 2018. 2.Garg S.K &Garg, Ecological and Environmental studies, Khanna Publishers, 2015. 3.Wright &Nebel, Environmental science towards a sustainable future, 12thEditon, Prentice Hall of India Ltd, 2015.
REFERENCE BOOKS: 1. ErachBharucha, "Text book of Environmental studies for Undergraduate courses", 3rd Edition, UGC, 2021. 2. Ravi P. Agrahari, Environmental ecology, Biodiversity, climatic change & Disaster management, 1st Edition, McGraw Hill, 2020 3. Benney Joseph, "Environmental Science and Engineering", 1st Edition, McGraw Hill Education (India) Pvt Ltd, New Delhi, 2017.

21MC101	BASIC CIVIL AND MECHANICAL ENGINEERING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To discuss the significance of the Civil and Mechanical Engineering Profession in satisfying the societal needs.
- To demonstrate the building materials and components used for construction.
- To compare different manufacturing processes and types of power plants.
- To explain the components of IC engines and their working principles.
- To explain the working principle of Refrigeration & Air-conditioning system

UNIT I	OVERVIEW OF CIVIL ENGINEERING	9

Civil Engineering contributions to the welfare of Society - Specialized sub disciplines in Civil Engineering – Structural, Construction, Geotechnical, Environmental, Transportation and Water Resources Engineering – National building code – Terminologists: Plinth area, Carpet area, Floor area, Buildup area, Floor space index.

UNIT II	CIVIL ENGINEERING MATERIALS AND BUILDING COMPONENTS	9

Civil Engineering Materials: Bricks – Stones – Sand – Cement – Concrete – Steel - Timber – Modern Materials, Thermal and Acoustic Insulating Materials, , Building plans – Setting out of a Building - Foundations: Types of foundations - Bearing capacity and settlement – Brick masonry – Stone Masonry – Beams – Columns.

UNIT III	MANUFACTURING PROCESSES AND POWER PLANTS	9
Materials for engineering components, stress, strain, Factor of safety. foundry - green sand mould casting. Metal joining – Arc welding and Gas welding-Classification of Power Plants- Working principle of steam, Gas, Diesel, Hydro -electric and Nuclear Power plants		
UNIT IV	**INTERNAL COMBUSTION ENGINES**	**9**
Internal combustion engines as automobile power plant – Working principle of Petrol and Diesel Engines – Four stroke and two stroke cycles – Comparison of four stroke and two stroke engines. Working principle of High Pressure Boilers- Reciprocating Pumps (single acting and double acting) and Centrifugal Pumps.		
UNIT V	**REFRIGERATION AND AIR CONDITIONING SYSTEM**	**9**
Terminology of Refrigeration and Air Conditioning. Principle of vapour compression and absorption system–Layout of typical domestic refrigerator–Window and Split type room Air conditioner.		
		TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course, the learners will be able to

CO1: Outline the Profession of Civil Engineering.

CO2: Summarize the planning of materials used for construction of building and its process.

CO3:Differentiate the Manufacturing Processes and power plants.

CO4:Discuss the Working Principles of IC Engine.

CO5: Describe the components of refrigeration and air conditioning cycle.

TEXT BOOKS:

1. Shanmugam G and Palanichamy M S, "Basic Civil and Mechanical Engineering", 4th Edition, Tata McGraw Hill, New Delhi 2018.
2. Venugopal K and Dr. V. Prabhu Raja "Basic Civil and Mechanical Engineering", Third Edition, Anuradha Publishers, Kumbakonam 2018.
3. Dr.R.Vaidyanathan and P.Perumal "Basic Civil and Mechanical Engineering", 2nd Edition, Laxmi Publishers Newdelhi,2016

REFERENCES:

1. Palanikumar, K. "Basic Civil and Mechanical Engineering", 2nd Edition, Cengage learning, 2012.
2. Ramamrutham S., "Basic Civil Engineering", 2nd Edition, Dhanpat Rai Publishing Co. Pvt. Ltd. 2013.
3. Seetharaman S., "Basic Civil Engineering", 2nd Edition, Anuradha Agencies, 2005
4. Shantha Kumar SRJ, "Basic Mechanical Engineering", 1st Edition, Hi-tech Publications, Mayiladuthurai, 2000.
5. Ramesh Babu.V., "Basic Civil and Mechanical Engineering", 1st Edition, VRB publisers pvt Ltd, 2017.

21TA102	TAMILS AND TECHNOLOGY / தமிழரும் தொழில்நுட்பமும் *(Common to all B.E./B.Tech. Programmes)*	L	T	P	C
		1	0	0	1
UNIT I	**WEAVING AND CERAMIC TECHNOLOGY**				**3**
Weaving Industry during Sangam Age – Ceramic technology – Black and Red Ware Potteries					

(BRW) – Graffiti on Potteries.

UNIT II	DESIGN AND CONSTRUCTION TECHNOLOGY	3

Designing and Structural construction House & Designs in household materials during Sangam Age - Building materials and Hero stones of Sangam age – Details of Stage Constructions in Silappathikaram - Sculptures and Temples of Mamallapuram - Great Temples of Cholas and other worship places - Temples of Nayaka Period - Type study (Madurai Meenakshi Temple)- Thirumalai Nayakar Mahal - Chetti Nadu Houses, Indo - Saracenic architecture at Madras during British Period

UNIT III	MANUFACTURING TECHNOLOGY	3

Art of Ship Building - Metallurgical studies - Iron industry - Iron smelting,steel -Copper and gold coins as source of history - Minting of Coins – Beads making-industries Stone beads -Glass beads - Terracotta beads -Shell beads/ bone beats - Archeological evidences - Gem stone types described in Silappathikaram.

UNIT IV	AGRICULTURE AND IRRIGATION TECHNOLOGY	3

Dam, Tank, ponds, Sluice, Significance of Kumizhi Thoompu of Chola Period, Animal Husbandry - Wells designed for cattle use - Agriculture and Agro Processing - Knowledge of Sea - Fisheries – Pearl - Conche diving - Ancient Knowledge of Ocean - Knowledge Specific Society.

UNIT V	SCIENTIFIC TAMIL & TAMIL COMPUTING	3

Development of Scientific Tamil - Tamil computing – Digitalization of Tamil Books – Development of Tamil Software – Tamil Virtual Academy – Tamil Digital Library – Online Tamil Dictionaries – Sorkuvai Project.

TOTAL: 15 PERIODS

TEXT-CUM-REFERENCE BOOKS :

1. தமிழக வரலாறு மக்களும் பண்பாடும் கே.கே.பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்)
2. கணினித்தமிழ் முனைவர் இல. சுந்தரம். (விகடன் பிரசுரம்).
3. கீழடி வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)
4. பொருநை ஆற்றங்கரை நாகரிகம். (தொல்லியல் துறை வெளியீடு)
5. Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
6. Social Life of the Tamils - The Classical Period (Dr.S.Singaravelu) (Published by: International Institute of Tamil Studies.
7. Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies.)
9. Keeladi - 'Sangam City Civilization on the banks of river Vaigai' (Jointly Published by: Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Published by: The Author)
11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)

12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

21EM101	ENGINEERING PRACTICES LABORATORY (Common to all B.E / B.Tech. Programmes)	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES:

- To draw pipe line plan; laying and connecting various pipe fittings used in common household plumbing work; Sawing; planing; making joints in wood materials used in common household wood work.
- To demonstrate the basic switch board wiring, fluorescent lamp wiring and stair case wiring using various electrical components.
- To choose various joints in steel plates using arc welding work and machining various simple processes like turning, drilling, tapping in parts
- To build a tray out of metal sheet using sheet metal work.
- To develop electronic circuit and testing for soldering and desoldering using PCB board.

LIST OF EXPERIMENTS:

GROUP – A (CIVIL & ELECTRICAL)

PART – I

CIVIL ENGINEERING PRACTICES

PLUMBING WORK:

- Connecting various basic pipe fittings like valves, taps, coupling, unions, reducers, elbows and other components which are commonly used in household.
- Preparing plumbing line sketches.
- Laying pipe connection to the suction side of a pump
- Laying pipe connection to the delivery side of a pump.
- Connecting pipes of different materials: Metal, plastic and flexible pipes used in household appliances.

WOOD WORK:

- Sawing,
- Planning and Making joints like T-Joint, Cross lap and Dovetail joint.

PART – II

ELECTRICAL ENGINEERING PRACTICES

- Introduction to switches, fuses, indicators and lamps - Basic switch board wiring with lamp, fan and three pin socket
- Staircase wiring
- Fluorescent Lamp wiring with introduction to CFL and LED types.
- Energy meter wiring and related calculations/ calibration
- Study of Iron Box wiring and assembly
- Study of Fan Regulator (Resistor type and Electronic type using Diac/Triac/quadrac)
- Measurement of resistance to earth of an electrical equipment.

GROUP – B (MECHANICAL & ELECTRONICS)
PART III
MECHANICAL ENGINEERING PRACTICES **WELDING WORK:** • Welding of Butt Joints, Lap Joints, and Tee Joints using arc welding. • Practicing gas welding. **BASIC MACHINING WORK:** • Usage of Spanners and screw drivers • Facing and Turning. • Taper Turning **ASSEMBLY WORK:** • Assembling a centrifugal pump. • Assembling a household mixer. • Assembling an air conditioner. **SHEET METAL WORK:** • Making of a square tray **FOUNDRY WORK:** • Demonstrating basic foundry operations.
PART IV
ELECTRONIC ENGINEERING PRACTICES **SOLDERING WORK:** • Soldering simple electronic circuits and checking continuity. **ELECTRONIC ASSEMBLY AND TESTING WORK:** • Assembling and testing electronic components on a small PCB. **ELECTRONIC EQUIPMENT STUDY:** • Study elements of smart phone. • Assembly and dismantle of computer / laptop
TOTAL: 60 PERIODS
COURSE OUTCOMES:
At the end of the course, learners will be able to CO1: Build various plumbing joints CO2: Develop various carpentry joints. CO3: Construct various wiring electrical joints in common household electrical wire work. CO4: Construct various welded joints, sheet metal and basic machining operations CO5: Develop the electronic circuit for soldering and testing using PCB board.

21EE102	ELECTRIC CIRCUITS LABORATORY	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES:

- To analyze various electric circuits using PSpice/ MATLAB/P-SIM.
- To apply basic electric circuit laws in electrical circuits.
- To experiment basic circuit theorems in electrical networks.
- To utilize the software for simulation of RL, RC and RLC circuits.

- To compare the frequency response of series and parallel resonant circuits

LIST OF EXPERIMENTS

1. Verification of Kirchhoff's voltage law.
2. Verification of Kirchhoff's current law.
3. Verification of Thevenin's theorem & Norton's theorem.
4. Verification of Superposition theorem & Maximum Power transfer Theorem.
5. Experimental validation of transient response of R-L, R-C circuit with DC and AC input.
6. Experimental validation of transient response of R-L-C circuit with DC and AC input
7. Design of series resonant circuit.
8. Design of parallel resonant circuit.
9. Verification of three phase balanced and unbalanced networks.
10. Measurement of Power in three phase circuits.
11. Simulation of three phase balanced and unbalanced star, delta network circuits.
12. Study of Analog and digital oscilloscope and measurement of sinusoidal voltage, frequency and power factor.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

At the end of the course, learners will be able to

CO1: Apply basic circuit laws for electric circuit parameters calculation

CO2: Choose circuit theorems for finding electric circuits parameters.

CO3: Classify the response of RL, RC and RLC circuits with AC and DC inputs.

CO4: Demonstrate the power and energy parameters for single and three phase AC circuits

CO5: Analyze the time and frequency response of series and parallel resonance circuits.

SEMESTER – III

21MA202	TRANSFORM TECHNIQUES AND ITS APPLICATIONS	L	T	P	C
		3	2	0	4

COURSE OBJECTIVES:

- To discuss the various methods to find the Laplace transform of the given function.
- To solve the given ODE problems using Laplace transform that occur in Electrical engineering discipline.
- To develop Z transform techniques to solve difference equations for discrete time systems.
- To explain the concept of Fourier transform techniques and its inverse
- To construct the Discrete Fourier transforms of the given sequence in Electrical engineering field.

UNIT I	LAPLACE TRANSFORM	12

Laplace transform- conditions for existence –Transform of elementary functions –Basic properties –First shifting theorem –Transform of derivatives on $t\,f(t), f(t)/t$ and periodic functions-Transform of unit step function and impulse functions. Inverse Laplace transform by partial fraction method.

UNIT II	APPLICATIONS OF LAPLACE TRANSFORM	12

Convolution theorem (excluding proof)-Initial and finial value theorems-Solutions of linear ODE of second order with constant coefficients using Laplace transform techniques-Application problems using Laplace Transform in Electrical Engineering.

UNIT III	Z- TRANSFORM	12

Z- Transform – Elementary properties – Inverse Z- Transforms (using partial fractions and residues) – Convolution theorem –Initial value and Final value theorem- Formation of difference equations – Solution of difference equations using Z-transform-Application problems using Z-Transform in Electrical Engineering.

UNIT IV	FOURIER TRANSFORM	12

Statement of Fourier integral theorem – Fourier transform pair – Fourier sine and cosine transform – Properties – Transforms of simple functions – convolution theorem – Parseval's identity.

UNIT V	APPLICATIONS OF FOURIER TRANSFORM	12

Application of Fourier transform to Boundary value problems, Discrete Fourier transform and its properties, Inverse Discrete Fourier transform and its properties - Discrete Time Fourier Transform and its properties -Inverse Discrete Time Fourier Transform and its properties - Application problems using Fourier Transform in Electrical Engineering.

TOTAL: 60 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to

CO1: Calculate interpret the Laplace Transform and inverse Laplace Transform of different functions.

CO2 :Apply Laplace Transform technique to solve second order differential equations with elementary functions.

CO3: Solve the given difference equations using Z Transform.

CO4: Use Fourier Transform techniques to calculate the given integral.

CO5**:** Choose suitable Fourier transform techniques to evaluate the given integral in wide variety of situations in Electrical Engineering.

TEXT BOOKS:

1. Erwin Kreyszig, "Advanced Engineering Mathematics ", 10th Edition, John Wiley, India, 2016.
2. R.C. Wylie, and Barrett, L.C., "Advanced Engineering Mathematics ", 6th Edition, Tata McGraw Hill Education Pvt. Ltd, New Delhi, 2012.
3. John A.Gubner, Probability and Random Process for Electrical and Computer Engineers, 3rd Edition, Cambridge University Press, New York, 2012.

REFERENCES:

1. B.S.Grewal, "Higher Engineering Mathematics", 44th edition, Khanna Publisher, Delhi.
2. Peter V.O'Neil, "Advanced Engineering Mathematics", 7th Edition, Cengage Learning India Private Limited, Delhi.
3. Li Tan, Digital Processing Fundamentals and Applications, 1st Edition, Academic Press, 2008.
4. P.Ramesh babu, Digital Signal processing, 4th Edition, SciTech Publications of India, 2013. (Unit II **:**1.39 - 1.53, 4.1 – 5.11.4) & (Unit V**:** 2.1 – 2.11)
5. T.Nageshwara Rao, Circuit Theory, 1st Edition, ARS Publications, (Unit III: 11.1-11.51), 2015.

21EE201	FIELD THEORY	L	T	P	C
		3	2	0	4

COURSE OBJECTIVES:

- To summarize the basic mathematical concepts related to electromagnetic vector fields.
- To explain the concepts of Electrostatic fields, electric flux density, electrical potential, capacitance, energy density and their applications.
- To infer the concept of Magneto static fields, magnetic flux density, vector potential, Inductance and its applications.
- To illustrate the different methods of EMF generation and Maxwell's equations of static and time varying field.
- To interpret the concepts of Electromagnetic waves and characterizing parameters

UNIT I	COORDINATE SYSTEM AND INTRODUCTION TO ELECTROSTATICS	15

Sources and effects of electromagnetic fields – Coordinate Systems – Vector fields –Gradient, Divergence, Curl – theorems and applications - Coulomb's Law –Force.

UNIT II	ELECTROSTATICS AND APPLICATIONS	15

Electric field intensity – Field due to discrete and continuous charges – Gauss's law and applications. Electric potential – Electric field and equipotential plots, Uniform and Non-Uniform field, Utilization factor – Electric field in free space, conductors, dielectrics - Dielectric polarization – Dielectric strength - Electric field in multiple dielectrics – Boundary conditions, Poisson's and Laplace's equations, Capacitance, Energy density, Applications. Simulation of Electric fields using FEM Packages.

UNIT III	MAGNETOSTATICS AND APPLICATIONS	15

Lorentz force, magnetic field intensity (H) – Biot–Savart's Law - Ampere's Circuit Law – H due to straight conductors, circular loop, infinite sheet of current, Magnetic flux density (B) – B in free space, conductor, magnetic materials – Magnetization, Magnetic field in multiple media –

Boundary conditions, scalar and vector potential, Poisson's Equation, Magnetic force, Torque, Inductance, Energy density, Applications. Simulation of Magnetic fields using FEM Packages.		
UNIT IV	**MOTIONAL/ TRANSFORMER EMF AND MAXWELL EQUATION OF ELECTRODYNAMIC FIELDS**	**15**
Magnetic Circuits - Faraday's law – Transformer and motional EMF – Displacement current - Maxwell's equations (differential and integral form) – Relation between field theory and circuit theory – Applications.		
UNIT V	**ELECTROMAGNETIC WAVES AND ITS PROPAGATION**	**15**
Electromagnetic wave generation and equations – Wave parameters; velocity, intrinsic impedance, propagation constant – Waves in free space, lossy and lossless dielectrics, conductors- skin depth - Poynting vector – Plane wave reflection and refraction.		
	TOTAL: 75 PERIODS	

COURSE OUTCOMES: At the end of the course, learners will be able to

CO1:Outline the basic mathematical concepts related to electromagnetic vector.

CO2:Summarize the basic concepts of electrostatic fields, electrical potential, energy density capacitance and their applications.

CO3:Infer the knowledge in magneto static fields, magnetic flux density, vector potential, Inductance and its applications.

CO4: Classify methods of EMF generation and Maxwell's equations of Electrodynamic fields.

CO5:Illustrate the basic concepts of electromagnetic waves and characterizing parameters.

TEXT BOOKS:

1. Mathew N.O. Sadiku, "Principles of Electromagnetics", 6th Edition, Oxford University Press Inc. Asian edition, 2015.
2. William H. Hayt and John A. Buck, "Engineering Electromagnetics", Special Indian Edition, McGraw Hill, 2014.
3. Kraus and Fleish, "Electromagnetics with Applications", McGraw Hill International Editions, 5thEdition, 2010.
4. K A Gangadhar, "Electromagnetic Field Theory", 8thEdition, Khanna Publishers, 2015

REFERENCES

1. V.V.Sarwate, "Electromagnetic fields and waves", 1stEdition, Newage Publishers, 2018
2. J.P.Tewari, "Engineering Electromagnetics - Theory, Problems and Applications", 2nd Edition, Khanna Publishers.
3. Joseph. A.Edminister, "Schaum's Outline of Electromagnetics", 3rd Edition (Schaum's Outline Series), McGraw Hill, 2010.
4. S.P.Ghosh, LipikaDatta, "Electromagnetic Field Theory", 1stEdition, McGraw Hill Education(India) Private Limited, 2012.

21EE202	DC MACHINES AND TRANSFORMERS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To illustrate the magnetic-circuit analysis and introduce magnetic materials.
- To develop constructional details, the principle of operation, prediction of performance, the methods of testing the transformers and three phase transformer connections.
- To explain the working principle of electrical machines using the concepts of

electromechanical energy conversion principle and derive expressions for generated voltage and torque developed in all Electrical Machines.

- To summarize the working principle of DC machines as Generator types, their no-load/load characteristics, starting and methods of speed control of motors.
- To outline various losses taking place in DC Motor and to study the different testing methods to evaluate their performance.

UNIT I	ELECTRO-MECHANICAL ENERGY CONVERSION	9

Fundamentals of Magnetic circuits- Statically and dynamically induced EMF - Principle of electromechanical energy conversion forces and torque in magnetic field systems- energy balance in magnetic circuits- magnetic force- co-energy in singly excited and multi excited magnetic field system– AC excitation - Introduction to permanent magnets

UNIT II	DC GENERATORS	9

Construction and components of DC Machine – Principle of operation - Lap and wave windings- EMF equations– Circuit model – Armature reaction –Methods of excitation- Commutation - Interpoles compensating winding –Characteristics of DC generators-Parallel operation of DC generators

UNIT III	DC MOTORS	9

Principle and operations - types of DC Motors – Speed Torque Characteristics of DC Motors- Starting and speed control of DC motors –Plugging, dynamic and regenerative braking- Losses & efficiency – Condition for maximum efficiency – Testing of DC machines – Retardation test- Swinburne's test and Hopkinson's test-applications of DC Motor.

UNIT IV	TRANSFORMERS	9

Construction – Principle of operation – Equivalent circuit parameters – Phasor diagrams, losses – auto transformer – Tap changing transformers- Tertiary winding-Instrument transformers- Three phase transformers-connections – Scott Connection-Phasing of transformer– applications.

UNIT V	TESTING OF TRANSFORMERS	9

Testing – polarity test, open circuit and short circuit tests, voltage regulation, losses and efficiency, all day efficiency, back-to-back test, separation of core losses, parallel operation of single-phase transformers

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to

CO1: Explain the magnetic-circuits.
CO2: Show the working principle of DC Generator.
CO3: Illustrate the working principle of DC Motor.
CO4: Build the knowledge in constructional details of transformers.
CO5: Demonstrate the testing of transformer.

TEXT BOOKS:

1. Nagrath, I.J. and Kothari.D.P., "Electric Machines", 6thEdition, McGraw-Hill Education, 2019.
2. P. S. Bimbhra, "Electrical Machines",4thEdition, Khanna Publishing, 2018.
3. Fitzgerald. A.E., Charles KingselyJr, Stephen D.Umans, "Electric Machinery", 7thEdition, McGraw- HillEducation, 2020.
4. Theraja B.L., "A Textbook of Electrical Technology, Volume II", 24thEdition, S. Chand Publication, 2018.

REFERENCES

1. B.R. Gupta, "Fundamental of Electric Machines", 4th Edition, New age International Publishers 2017.
2. S.K. Bhattacharya, "Electrical Machine",4th Edition McGraw - Hill Education, ,2018
3. Theodore Wildi, "Electrical Machines, Drives, and Power Systems", 7th Edition, Pearson Education., 2017.
4. Ashfaq Husain, HarroonAshfaq, "Electrical Machines", 4th Edition,DhanpatRai& Sons Ltd, 2018

21EE203	TRANSMISSION AND DISTRIBUTION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To explain the structure of electric power system with transmission line parameters.
- To utilize the methodology for regulation and efficiency in transmission lines.
- To illustrate mechanical design of transmission lines and insulator strings.
- To outline the types, construction and grading of cables.
- To summarize the types of substations and methods of grounding.

UNIT I	TRANSMISSION LINE PARAMETERS	9

Structure of power System - parameters of single and three phase transmission lines with single and double circuits - resistance, inductance and capacitance of solid, stranded and bundled conductors, symmetrical and unsymmetrical spacing and transposition - application of self and mutual GMD; Skin and Proximity effects -Typical configurations, conductor types and electrical parameters of EHV lines.

UNIT II	MODELLING AND PERFORMANCE OF TRANSMISSION LINES	9

Performance of transmission lines - short line, medium line and long line - equivalent circuits, phasor diagram, attenuation constant, phase constant, Surge impedance Loading (SIL) - transmission efficiency and voltage regulation, real and reactive power flow in lines - Power Circle diagrams – ABCD parameters of transmission lines.

UNIT III	MECHANICAL DESIGN OF LINES	9

Mechanical design of over head lines – Line Supports –types of towers – stress and sag Calculation – effects of wind and ice loading. Insulators – types - voltage distribution in insulator string - improvement of string efficiency - testing of insulators - formation of Corona – Critical Voltages – effect on line performance.

UNIT IV	UNDERGROUND CABLES	9

Underground cables - types of cables – construction of single core and 3 core cables - insulation resistance – potential Gradient - capacitance of Single-core and 3 core cables – grading of cables - power factor and heating of cables– DC cables.

UNIT V	DISTRIBUTION SYSTEMS	9

Distribution Systems – General Aspects – Kelvin's Law – AC and DC distributions - Techniques of voltage Control and power factor improvement – distribution Loss –types of substations - methods of grounding –EHVAC, HVDC and FACTS (Qualitative treatment only).

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to

CO1: Outline the importance and the functioning of transmission line parameters.

CO2: Identify the performance of transmission lines based on the length and environmental aspects.
CO3: Explain the mechanical design of transmission lines and formation of corona.
CO4: Illustrate about the insulators and cables based on the transmission voltage capacity.
CO5: Compare the concepts of electric distribution system such as EHVAC, HVDC and FACTS.

TEXT BOOKS:

1. D.P.Kothari, I.J.Nagarath, "Power System Engineering", 3rdEdition, McGraw-Hill Publishing Company limited, New Delhi, 2019.
2. S.N. Singh, "Electric Power Generation, Transmission and Distribution", 4thEdition, Prentice Hall of India Pvt. Ltd, New Delhi, 2016.
3. C.L.Wadhwa, "Electrical Power Systems", 6thEdition, New Academic Science Ltd, 2019.
4. V.K.Mehta, Rohit Mehta, "Principles of power system", 1stEdition revised. S Chand & Company Ltd, New Delhi, 2019.

REFERENCES:

1. B.R.Gupta, 'Power System Analysis and Design' S. Chand, New Delhi, 5th Edition, 2008.
2. Luces M.Fualkenberry, WalterCoffer,'Electrical Power Distribution and Transmission', 1st Edition, Pearson Education, 2007.
3. ArunIngole, "Power transmission and distribution", 1st Edition, Pearson Education, 2017.
4. J.Brian, Hardy and Colin R.Bayliss 'Transmission and Distribution in Electrical Engineering', Newnes; 4th Edition, 2012.
5. G.Ramamurthy, "Handbook of Electrical power Distribution," 1st Edition, Universities Press, 2013.

21EE204	ELECTRONIC DEVICES AND CIRCUITS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To explain the structure of basic Electronic Devices.
- To infer the operation and applications of Bipolar Junction Transistor (BJT) and Field Effect Transistor (FET).
- To summarize the concept of amplifiers and its biasing.
- To interpret the gain and frequency response of different amplifiers.
- To demonstrate the working principle of various wave shaping circuits.

UNIT I	DIODES, SPECIAL DIODES AND APPLICATIONS	9

PN Junction diode, V-I characteristics, applications, Half wave and full wave rectifiers with filter, clipper and clamper circuits. Zener diodes, working principle, Breakdown mechanism-application- Light Emitting Diode (LED), photo diode.

UNIT II	BIPOLAR AND UNIPOLAR JUNCTION TRANSISTOR	9

Bipolar Junction Transistor (BJT) and Uni Junction Transistor (UJT) – structure, operation and V-I characteristics – Junction Field Effect Transistor (JFET) – structure, operation and V-I characteristic, Current Equation, Metal Oxide Semiconductor Field Effect Transistor (MOSFET) – structure, operation and V-I characteristic – types of MOSFET-Applications of BJT and UJT.

UNIT III	AMPLIFIERS	9
BJT small signal model – biasing – analysis of Common Emitter (CE), Common Base (CB), Common Collector (CC) amplifiers – Gain and frequency response – MOSFET small signal model – biasing – analysis of Common source and source follower – gain and frequency response.		
UNIT IV	**MULTISTAGE AMPLIFIERS AND DIFFERENTIAL AMPLIFIER**	**9**
BIMOS cascade amplifier, differential amplifier – common mode and differential mode analysis – tuned amplifiers – single tuned amplifier – gain and frequency response, power amplifier.		
UNIT V	**FEEDBACK AMPLIFIERS, OSCILLATORS AND WAVE GENERATING CIRCUITS**	**9**
Advantages of negative feedback – voltage / current, series and shunt feedback – positive feedback – Condition for oscillations, Phase shift – Wien bridge, Hartley, Colpitt and Crystal oscillators- Multivibrator - Astable- Monostable- Bistable.		
	TOTAL: 45 PERIODS	

COURSE OUTCOMES: At the end of the course, learners will be able to

CO1: Outline the structure, operation and V- I characteristics of various PN diodes.

CO2: ExplainV-I characteristics of Bipolar Junction Transistor (BJT) and Field Effect Transistor (FET).

CO3**:** Identify the transistor application as amplifiers.

CO4: Infer the operation, characteristics and gain of multistage and differential amplifiers.

CO5: Summarize the operation of feedback amplifiers with their applications.

TEXT BOOKS:

1. David A. Bell, "Electronic devices and circuits", 5th Edition Prentice Hall of India, 2004.
2. S. Salivahanan, N. Suresh Kumar, "Electronic Devices and Circuits", 3rd Edition, Tata McGraw Hill 2012.
3. Floyd, "Electron Devices", 5th Edition, Pearson Asia, 2001.
4. Robert L. Boylestad, "Electronic Devices and Circuit theory", 11th Edition, Pearson Asia 2012.

REFERENCES

1. Adel S. Sedra , Kenneth C. Smith, "Microelectronic Circuits: Theory and Applications", 7th Edition, Oxford press, 2017.
2. Donald A. Neamen, "Electronic Circuit Analysis and Design", 3rd Edition, Tata McGraw Hill, 2003.
3. Dale R. Patrick , Stephen W. Fardo, "Electricity and Electronics Fundamentals", 2nd Edition , The Fairmont Press Inc, 2008.
4. Jacob Millman , Christos Halkias , "Electronic Devices And Circuits", 4th Edition, McGraw Hill India, 2015.

21EE205	DIGITAL LOGIC CIRCUITS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To summarize the various number systems and digital logic families.
- To build combinational logic circuits using K-map.
- To model synchronous sequential circuits using flip flops.
- To develop asynchronous sequential circuits using flip flops.
- To demonstrate the hardware functionality using Programmable Logic Devices (PLDs) and Hardware Description Language (HDL) at system level.

UNIT I	NUMBER SYSTEMS AND DIGITAL LOGIC FAMILIES	9

Review of number systems, binary codes, error detection and correction codes (Parity and Hamming code) - Digital Logic Families -comparison of Resistor Transistor Logic (RTL), Diode Transistor Logic (DTL), Transistor Transistor Logic (TTL), Emitter Coupled Logic (ECL) and Metal Oxide Semiconductor (MOS families) –operation- characteristics.

UNIT II	COMBINATIONAL LOGIC DESIGN	9

Combinational logic-Representation of logic functions- Sum of product (SOP) and Product of sum (POS) forms. Simplification of logic functions through Karnaugh map (K-maps), Implementation of Decoders, Encoders, Multiplexers and Demutiplexers using logic gates, Code converters, Adders, Subtractors.

UNIT III	SYNCHRONOUS SEQUENTIAL CIRCUITS	9

Sequential logic- Set Rest (SR), Jack Killby (JK), Delay (D) and Toggle (T) flip flops - level triggering and edge triggering - counters - asynchronous and synchronous type - Modulo counters - Shift registers - design of synchronous sequential circuits – Moore and Mealy models- State diagram-State reduction.

UNIT IV	ASYNCHRONOUS SEQUENTIAL CIRCUITS	9

Asynchronous sequential logic circuits-Transition Stability, flow Stability-race conditions, hazards &errors in digital circuits- analysis of asynchronous sequential logic circuits.

UNIT V	PROGRAMMABLE LOGIC DEVICES AND HARDWARE DESCRIPTION LANGUAGE (HDL)	9

Introduction to Programmable Logic Devices: Programmable Read Only Memory (PROM) – Programmable Logic Array (PLA) –Programmable Array Logic (PAL)-Field Programmable gate Array (FPGA). Introduction to Hardware Description Language (HDL): Digital design process flow – Entities - Architecture –Concurrent and Sequential statements - Behavioral, Dataflow, and structural modeling-simple HDL codes.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to

CO1: Outline the various number systems and different logic families.

CO2:Build combinational logic circuits using basic gates and simplification using Karnaugh maps.

CO3: Model synchronous sequential circuits using flip flops.

CO4: Develop asynchronous sequential circuits using flip flops.

CO5: Explain the hardware functionality at system level using Programmable Logic device (PLD) and Hardware Description Language (HDL).

TEXT BOOKS:

1. M. Morris Mano , Michael D. Ciletti, "Digital Design - With an Introduction to the Verilog HDL, VHDL, and System Verilog", 6th Edition, McGraw Hill,2018.
2.Rabaey, "Digital Integrated Circuits: A design perspective", 2nd Edition, Pearson Education, 2016.
3. Thomas L. Floyd, "Digital Fundamentals", 11th Edition, Pearson Education, 2017.
4. S. Salivhanan, S. Arivazhagan, "Digital Circuits and Design",5th Edition, Oxford University Press, 2018.

REFERENCES:

1. Leach, Malvino, Saha, "Digital Principles and Applications", 8th Edition,McGraw Hill, 2014.
2. William Keitz, "Digital Electronics-A Practical Approach with VHDL", 9th Edition, Pearson, 2011.
3.Samir Palnitkar, "Verilog HDL- A guide to digital design and synthesis", 2nd Edition, Pearson education, 2003.
4. Ronald J. Tocci , "Digital Systems", 10th Edition, Pearson education, 2009.

21EE206	DC MACHINES AND TRANSFORMERS LABORATORY	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES:

- To identify the performance characteristics of DC Generator.
- To develop the performance characteristics of DC Motor.
- To experiment with DC machines to predetermine their performance.
- To make use of speed control techniques in DC motors.
- To build the performance characteristics of Transformers.

LIST OF EXPERIMENTS

1. Open circuit and load characteristics of DC shunt generator- critical resistance and critical speed.
2. Load characteristics of DC compound generator with differential and cumulative connections.
3. Load test on DC shunt motor.
4. Load test on DC compound motor.
5. Load test on DC series motor.
6. Swinburne's test and speed control of DC shunt motor.
7. Hopkinson's test on DC motor – generator set.
8. Load test on single-phase transformer and three phase transformers.
9. Open circuit and short circuit tests on single phase transformer.
10. Sumpner's test on single phase transformers.
11. Separation of no-load losses in single phase transformer.
12. Transformer polarity and vector group test.

TOTAL: 60 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to

CO1: Identify the performance characteristics of DC Generator.

CO2: Develop the performance characteristics of DC Motor.

CO3: Experiment with DC machines to predetermine their performance.
CO4: Make use of speed control techniques in DC motors.
CO5: Build the performance characteristics of Transformers.

21EE207	ELECTRONIC DEVICES AND DIGITAL LABORATORY	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES:

- To identify the behavior of semiconductor devices and its applications.
- To develop the VI characteristics of bipolar and unipolar devices.
- To build combinational and sequential circuits using digital IC.
- To model synchronous and asynchronous counters.
- To construct shift registers.

LIST OF EXPERIMENTS

1. Characteristics of diode and its applications
2. Characteristics of a current controlled devices and its applications
3. Characteristics of voltage controlled devices and its applications
4. Characteristics of Uni Junction Transistor (UJT) and generation of sawtooth waveforms using UJT.
5. Design and implementation of Boolean Functions, Adder and Subtractor circuits.
6. Design and implementation of code converters: Binary to Gray code converter and vice-versa
7. Design and implementation of multiplexer and demultiplexer
8. Design and implementation of parity generator and parity checking
9. Design and implementation of encoders and decoders
10. Design and implementation of 3-bit counters.
11. Design and implementation of 4-bit shift registers

TOTAL: 60 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to

CO1: Identify the VI characteristics of semiconductor diodes.
CO2: Develop the VI characteristics of bipolar and unipolar devices.
CO3: Construct combinational circuits using basic gates.
CO4: Model synchronous and asynchronous counters using JK flip flop.
CO5: Build shift registers using delay flipflop.

SEMESTER – IV

21MA207	STATISTICS AND NUMERICAL METHODS	L	T	P	C
		3	2	0	4

COURSE OBJECTIVES:

- To discuss the basic concepts of statistics.
- To demonstrate the basic concepts of solving algebraic and transcendental equations.
- To explain the numerical techniques of interpolation in various intervals.
- To make use of numerical techniques to evaluate the approximation of derivatives and integral which plays an important role in engineering and technology disciplines.
- To develop the knowledge of various numerical techniques and methods of solving ordinary differential equations.

UNIT I	STATISTICS	12

Measures of central tendency – Mean – Median – Mode – Geometric mean and Harmonic mean – Measures of dispersion – range - Quartile deviation – mean deviation and standard deviation – correlation – coefficient of correlation - lines of regression.

UNIT II	SOLUTION OF EQUATIONS AND EIGENVALUE PROBLEMS	12

Solution of algebraic and transcendental equations – Methods of False position– Newton Raphson method- Crout's method-Types of Errors approximations-Solution of linear system of equations – Gauss Jordan method – Iterative method-Gauss Seidel - Eigen values of a matrix by Power method .

UNIT III	INTERPOLATION AND APPROXIMATION	12

Difference Operators-Forward, Backward, Shift operator- Interpolation with equal intervals - Newton's forward and backward difference formulae-Interpolation with unequal intervals - Lagrange's interpolation – Newton's divided difference interpolation.

UNIT IV	NUMERICAL DIFFERENTIATION AND INTEGRATION	12

Approximation of derivatives using interpolation polynomials - Numerical integration using Newton's Cote's formula, Trapezoidal, Simpson's 1/3 rule, $3/8^{th}$ rule – Two point and three point Gaussian quadrature formulae.

UNIT V	INITIALVALUE PROBLEMS FOR ORDINARY DIFFERENTIAL EQUATIONS	12

Single Step methods – Taylor's series method – Euler's method - Modified Euler's method - Fourth order Runge-Kutta method for solving first order equations - Multi step methods – Milne's and Adams-Bash forth predictor corrector methods for solving first order equations.

TOTAL: 60 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to

CO1: Experiment the various measures of central tendency and measures of dispersion.

CO2: Apply the basic concepts and techniques of solving algebraic and transcendental equations.

CO3: Apply the numerical techniques of interpolation and error approximations in various intervals in real life situations

CO4: Make use of a suitable numerical techniques to evaluate the approximation of derivatives and integral.

CO5**: S**olve the IVPs in ODE using single step and multi-step methods.

TEXT BOOKS:

1. Johnson, R.A., Miller, I and Freund J, "Probability and Statistics for Engineers", 8th Edition, Pearson Education, Asia, 2015.
2. Steven C. Chapra, Raymond P. Canale, "Numerical Methods for Engineers", 6th Edition, MC Graw Hill Higher Education, 2010.
3. Burden,R.L and Faires,J.D,"Numerical Analysis", 9th Edition, Cengage Learning, 2016.
4. Gerald.C.F and Wheatley.P.O.,"Applied Numerical Analysis", 6th Edition, Pearson Education , 2006

REFERENCES:

1. Joe.D. Hoffman, Steven Frankel, Numerical Methods for Engineers and Scientists" 3rd Edition, CRC Press, 2015.
2. Mathews,J.H. "Numerical Methods for Mathematics, Science and Engineering ", 2nd Edition, Prentice Hall,1992.
3. S.K.Gupta, "Numerical methods for Engineers", 1st Edition, New Age Internationals Private Ltd Publishers, 2015.

21EE208	MEASUREMENTS AND INSTRUMENTATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To explain the basic functional elements of instrumentation
- To demonstrate various electrical and electronic instruments
- To outline various measurement techniques
- To summarize various storage and display devices
- To illustrate various transducers principle and data acquisition systems

UNIT I	QUALITIES OF MEASUREMENTS	9

Functional elements of an instrument – Static and dynamic characteristics – Errors in measurement – Statistical evaluation of measurement data – Standards and calibration.

UNIT II	ELECTRICAL AND ELECTRONICS INSTRUMENTS	9

Principle and types of analog and digital voltmeters, ammeters, multimeters – Single and three phase wattmeters and energy meters – Magnetic measurements – Determination of B-H curve and measurements of iron loss – Instrument transformers – Instruments for measurement of frequency and phase.

UNIT III	COMPARATIVE METHODS OF MEASUREMENTS	9

D.C potentiometers, D.C & A.C bridges, transformer ratio bridges, self-balancing bridges. Interference & screening – Multiple earth and earth loops - Electrostatic and electromagnetic Interference – Grounding techniques.

UNIT IV	STORAGE AND DISPLAY DEVICES	9

Magnetic disk and tape – Recorders, digital plotters and printers, CRT display, digital CRO, LED, LCD & Dot matrix display – Data Loggers.

UNIT V	TRANSDUCERS AND DATA ACQUISITION SYSTEMS	9

Classification of transducers – Selection of transducers – Resistive, capacitive & inductive Transducers – Piezoelectric, Hall effect, optical and digital transducers – Elements of data acquisition system – Smart sensors-Thermal Imagers.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to

CO1: Outline the basic concepts about measurement and instrumentation.

CO2: Illustrate the operating principles of MI and MC meters.

CO3: Classify the methods of measurements for Resistance, Inductance and Capacitance using bridges.

CO4: Interpret elements of digital storage & display devices.

CO5: Explain the functioning of transducers and data acquisition systems.

TEXT BOOKS:

1. A.K. Sawhney, "A Course in Electrical & Electronic Measurements & Instrumentation", 5th Edition, DhanpatRai and Co, 2010.
2. J. B. Gupta, "A Course in Electronic and Electrical Measurements", 2nd Edition, S.K.Kataria & Sons, Delhi, 2013.
3. Doebelin E.O. and Manik D.N., "Measurement Systems – Applications and Design", Special Indian Edition, McGraw Hill Education Pvt. Ltd., 2007.
4. H.S. Kalsi, "Electronic Instrumentation", 3rd Edition, McGraw Hill, 2010.

REFERENCES

1. D.V.S. Murthy, "Transducers and Instrumentation", 2nd Edition, Prentice Hall of India Pvt Ltd, 2015.
2. David Bell, "Electronic Instrumentation & Measurements", 3rd Edition, Oxford University Press, 2013.
3. Martin Reissland, "Electrical Measurements", 2nd Edition, New Age International (P) Ltd., Delhi, 2001.
4. Alan. S. Morris, "Principles of Measurements and Instrumentation", 2nd Edition, Prentice Hall of India, 2003.

21EE209	INDUCTION AND SYNCHRONOUS MACHINES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To identify the operation and performance of three phase induction motor.
- To illustrate the speed control techniques in three-phase induction motors.
- To develop operation and performance of single phase induction motors.
- To construct the performance of salient and non – salient type synchronous generators.
- To build the operation and performance of synchronous motor.

UNIT I	THREE PHASE INDUCTION MOTOR	9

Constructional details – Types of rotors - Principle of operation – Slip – Torque-Slip characteristics - Condition for maximum torque – Load test- Losses and efficiency- Cogging and crawling - No load and blocked rotor tests - Equivalent circuit - Separation of losses - Circle diagram – Double cage induction motors –Induction generators– Introduction to Synchronous Induction Motor

UNIT II	STARTING AND SPEED CONTROL OF THREE PHASE INDUCTION MOTOR	9

Need for starting – Types of starters – DOL, Rotor resistance, Autotransformer and Star- delta starters -Korndorfer starter– Speed control – Voltage control, Frequency control and pole changing – Cascaded connection-V/f control – Slip power recovery scheme-Braking of three phase induction motor: Plugging, dynamic braking and regenerative braking.

UNIT III	SINGLE PHASE INDUCTION MOTORS AND SPECIAL MACHINES	9

Constructional details of single phase induction motor – Double field revolving theory and operation – Equivalent circuit – No load and blocked rotor test – Performance analysis – Starting methods of single-phase induction motors – Capacitor-start capacitor run Induction motor- Shaded pole induction motor - Repulsion motor - Hysteresis motor - AC series motor- Servo motors- Stepper motors - Linear Induction Motor.

UNIT IV	SYNCHRONOUS GENERATOR	9

Constructional details – Salient and non-salient types of rotors –Winding factors- EMF equation – Synchronous reactance – Armature reaction – Phasor diagrams of non-salient pole synchronous generator connected to infinite bus –Parallel operation of Alternators - Synchronization and load division- Synchronizing torque -Change of excitation and mechanical input- Voltage regulation – EMF, MMF, ZPF – Steady state power- angle characteristics– Two reaction theory –Slip test- Capability Curves

UNIT V	SYNCHRONOUS MOTOR	9

Principle of operation – Torque equation – Operation on infinite bus bars - V and Inverted V curves – Power input and power developed equations – Starting methods – Current loci for constant power input, constant excitation and constant power developed-Hunting – Natural frequency of oscillations – Damper windings- Synchronous condenser – Introduction to Permanent Magnet Synchronous Motor

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to

CO1: Build the construction and working principle of Three phase Induction Motor
CO2: Summarize the speed control techniques of three phase induction motors.
CO2: Model the single phase induction motor with construction and working principle
CO4: Identify the construction and working principle of Synchronous Generator.
CO5: Develop knowledge on Synchronous motor.

TEXT BOOKS:

1. Nagrath, I.J. and Kothari.D.P., "Electric Machines", 6th Edition, McGraw-Hill Education, 2019.
2. P. S. Bimbhra, "Electrical Machines", 4th Edition, ,Khanna Publishing, 2018
3. A.E. Fitzgerald, Charles Kingsley, Stephen. D. Umans, "Electric Machinery", 2nd Edition, McGraw Hill publishing Company Ltd, 2003.
4. Theraja B.L., "A Textbook of Electrical Technology", Volume II, 24th Edition, S. Chand Publication, 2018

REFERENCES

1. B.R. Gupta, "Fundamental of Electric Machines", 4th Edition, New age International Publishers, 2017.
2. S.K. Bhattacharya, "Electrical Machines", 4th Edition, McGraw - Hill Education, ,2018
3. M. G. Say, "Performance and Design of Alternating Current Machines", 3rd Edition, CBS

Publishers & Distributors Pvt. Ltd., New Delhi, 2002.
4. Miller, T.J.E., "Brushless Permanent Magnet and Reluctance Motor Drives", 1st Edition, Clarendon Press, 1989.

21EE210	CONTROL SYSTEMS	L	T	P	C
		3	2	0	4

COURSE OBJECTIVES:

- To explain the use of transfer function models for analysis of physical systems and introduce the control system components.
- To infer the time response of systems and steady state error analysis.
- To summarize the open loop and closed–loop frequency responses of systems.
- To illustrate stability analysis and design of compensator networks.
- To outline the state variable representation of physical systems

UNIT I	REPRESENTATION OF VARIOUS SYSTEMS	15

Elements and Types of Control Systems - Effect of Feedback Systems - Differential equation of Physical Systems – Mechanical Systems, Electrical Systems, Analogous Systems. Determination of transfer function by block diagram reduction technique and signal flow graph.

UNIT II	TIME RESPONSE OF FEEDBACK CONTROL SYSTEMS	15

Standard test signals - Unit step response of First and Second Order Systems - Time response specifications - Time response specifications of second order systems - steady state error and error constants -Introduction to PI, PD and PID Controllers and its effects (excluding design).

UNIT III	FREQUENCY DOMAIN ANALYSIS AND STABILITY	15

Correlation between time and frequency response - Bode Plot -Experimental determination of transfer function. Introduction to Polar Plots (Inverse Polar Plots excluded) - Mathematical preliminaries - Nyquist Stability criterion - assessment of relative stability: gain margin and phase margin

UNIT IV	STABILITY ANALYSIS & COMPENSATION TECHNIQUES	15

Concepts of stability - Necessary conditions for Stability - Routh-Hurwitz stability criterion - Introduction to Root-Locus Techniques - The root locus concept - Construction of root loci – Design of lag, lead and lead-lag compensating networks.

UNIT V	STATE VARIABLE ANALYSIS	15

Concept of state variables – State models for linear and time invariant Systems – Solution of state and output equation in controllable canonical form – Concepts of controllability and observability.

TOTAL: 75 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to

CO1: Develop transfer function of systems based on the knowledge of Mathematics, Science and Engineering fundamentals.

CO2: Apply the various time domain and frequency domain techniques to assess the system performance.

CO3: Identify the effect of various compensation in frequency domain.

CO4: Make use of knowledge about various stability techniques to different applications

CO5: Solve Controllability and Observability using state space representation.

TEXT BOOKS:

1. Nagarath, I.J. and Gopal, M., "Control Systems Engineering", 4th Edition, New Age International Publishers, 2017.
2. Benjamin C. Kuo, "Automatic Control Systems", 9th Edition, Wiley, 2009.
3. M.Gopal, "Control System: Principle and design", 4th Edition, McGraw Hill Education, 2012.
4. Katsuhiko Ogata, "Modern Control Engineering", 5th Edition, Pearson Education, 2015.

REFERENCES

1. Richard C.Dorfand Bishop, R.H., "Modern Control Systems", 12th Edition, Pearson Education, 2010.
2. John J.D., Azzo Constantine, H. and HoupisSttuart, N Sheldon, "Linear Control System Analysis and Design with MATLAB", 5th Edition, CRC Taylor& Francis Reprint 2017.
3. RamesC.Panda and T. Thyagarajan, "An Introduction to Process Modelling Identification and Control of Engineers", 2nd Edition, Narosa Publishing House, 2017.
4. A.Nagoorkani, "Control systems", 3rd Edition, RBA Publications 2017.

21EE211	INTEGRATED CIRCUITS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To outline the fabrication steps of integrated circuits and characteristics of Op-Amp
- To demonstrate the basic applications of Op-amp based circuits.
- To summarize the function of Op-Amp as comparator, wave generator and data converter.
- To explain the internal structure of special ICs such as 555 Timers, PLL circuits.
- To illustrate the functional blocks and applications of IC voltage regulator

UNIT I	INTEGRATED CIRCUIT (IC) FABRICATION AND OPERATIONAL AMPLIFIER CHARACTERISTICS	9

IC classification, fundamental of monolithic IC technology, epitaxial growth, masking and etching, diffusion of impurities. Realization of monolithic ICs and packaging. Fabrication of diodes, capacitance, resistance, Field Effect Transistors (FETs) and Photo Voltaic (PV) Cell. Ideal Operational amplifier of characteristics, DC characteristics and AC characteristics, differential amplifier; frequency response of Op-Amp

UNIT II	APPLICATIONS OF OPAMP	9

Basic applications of Op-Amp – Inverting and Non-inverting Amplifiers, summer, differentiator and integrator- Voltage – Current (V/I) and Current –Voltage (I/V) converters, Instrumentation amplifier, AD623 Instrumentation Amplifier and its application as load cell weight measurement - Log and Antilog Amplifiers-First and second order active filters

UNIT III	COMPARATOR, WAVE GENERATOR AND CONVERTER	9

Comparators, multivibrators, waveform generators, clippers, clampers, rectifiers, peak detector, Sample and Hold (S&H) circuit, Digital to Analog (D/A) converter, Analog to Digital (A/D) converters using Op-Amps.

UNIT IV	SPECIAL ICs	9

Functional block, characteristics of 555 Timer and its Pulse Width Modulation (PWM) application - IC566 Voltage Controlled Oscillator (VCO) IC565-Phase Locked Loop (PLL),

AD633 Analog multiplier IC.		
UNIT V	**IC REGULATORS**	**9**
IC voltage regulators –LM78XX, LM79XX; Fixed voltage regulators its application as Linear power supply - LM317, 723 Variable voltage regulators, switching regulator- Switched Mode Power Supply (SMPS).		
	TOTAL: 45 PERIODS	

COURSE OUTCOMES: At the end of the course, learners will be able to

CO1: Explain the steps involved in IC fabrication and characterization of Op-Amp

CO2: Outline the basic applications of Op-Amp.

CO3: Summarize the role of Op-Amp in wave generator, comparator and converter circuit.

CO4: Classify special ICs namely Timers and Phase locked Loop (PLL) circuits with their applications.

CO5: Interpret the role of ICs in voltage regulating circuits.

TEXT BOOKS:

1. D. Roy Choudhary, Sheil B. Jani, "Linear Integrated Circuits", 5th Edition , New Age, 2018.
2. S. Salivahanan, "Linear Integrated Circuits", 2nd Edition, Tata McGraw Hill, 2015.
3. Ramakant A. Gayakwad, "Op-Amps and Linear Integrated Circuits", 4th Edition, Pearson education, 2015.
4. Robert F. Coughlin, Fredrick F. Driscoll, "Op-amp and Linear ICs", 6th Edition, Pearson education, 2012.

REFERENCES:

1. Sergio Franco, "Design with Operational Amplifiers and Analog Integrated Circuits", 4th Edition, McGraw Hill, 2016.
2. David A. Bell, "Operational Amplifiers & Linear ICs", 3rd Edition, Oxford Higher education, 2011.
3. G B Clayton, Steve Winder, "Operational Amplifiers", 5th Edition, Newnes, 2003.
4. William D. Stanley, "Operational Amplifiers with Linear Integrated Circuits", 4th Edition, Pearson education, 2004.

21EE212	**MICROPROCESSORS, MICROCONTROLLERS AND INTERFACING (Theory with Practical Course)**	**L**	**T**	**P**	**C**
		3	**0**	**2**	**4**

OBJECTIVES:

- To illustrate the architecture of 8086 Microprocessor for programming concepts.
- To apply the interfacing concepts of IO/Memory and Serial / Parallel Communication with 8086 processor.
- To explain the architecture for programming in 8051 Microcontroller.
- To develop programming skills using 8051 Microcontroller.
- To infer the interfacing concepts of real time applications using microcontrollers.

UNIT I	**ARCHITECTURE OF 8086 & ASSEMBLY LANGUAGEPROGRAMMING**	**9**
Microprocessor Families – 8086 –Architecture – Instruction set – Addressing Modes – Bus Cycles – Assembly Language Programming of 8086 – Assembler Directives – Interrupts and its applications.		

UNIT II	PERIPHERAL INTERFACING	9
External Memory Interface – Programmable Peripheral Interface (8255) – Serial Communication Interface (8251) –Keyboard and Display Interface (8279) – Programmable Timer Controller (8254) – Programmable interrupt controller (8259).		
UNIT III	**8051 MICROCONTROLLER**	**9**
8051 Microcontroller –Architecture –Special Function Registers – Addressing modes-Instruction classification– Assembly Language Programming.		
UNIT IV	**8051 MICROCONTROLLER INTERFACING**	**9**
Ports – I/ O Interfacing –8051 Timer/ Counter mode selection – USART – Interrupt controller - DAC – ADC – Keyboard display Interfacing.		
UNIT V	**SYSTEM DESIGN USING MICROCONTROLLERS**	**9**
8051 Interfacing – Sensor Interfacing – RTC interfacing (DS1307) using I^2C standard – Relay, motor control- DC & Stepper Motor interfacing – Traffic Light Controller & Digital Weighing Machine control.		
	TOTAL: 45 PERIODS	
PRACTICAL COURSE		**15**

LIST OF EXPERIMENTS

Develop the 8086 Assembly Language Programming (ALP) for

1. Basic arithmetic and Logical operations
2. Code conversion, decimal arithmetic and Matrix operations.

Build the interfacing circuits for different I/Os with8086 microprocessor using

3. Serial interface and Parallel interface
4. Key board and Display Interface

Develop the 8051 Assembly Language Programming(ALP) and C programming for

5. Basic arithmetic and Logical operations
6. Finding Square and Cube of the given number program
7. Timer mode selection Programming
8. ADC / DAC interfacing
9. Keyboard display interfacing Programming
10. Unpacked BCD to ASCII

TOTAL: 60 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to

CO1: Develop assembly language program for 8085 & 8086 Microprocessor.

CO2: Build assembly language program and embedded C language program for 8051 Microcontroller.

CO3: Experiment with embedded C language program for MSP430 Microcontroller.

CO4: Make use of peripheral devices to interface 8086 microprocessor, 8051 and MSP430 Microcontroller.

CO5: Identify real time applications using 8086 microprocessor based systems, 8051 and MSP430 Microcontroller based systems.

TEXT BOOKS:

1. Douglas V Hall, "Microprocessors and Interfacing", 3rd Edition, McGraw Hill Education, 2012.
2. Muhammad Ali Mazidi, "The 8051 Microcontroller and Embedded Systems using

Assembly and C", 2nd Edition, Pearson India, 2007.

3. John Peatman, "Design with 8051 Microcontroller", 4th Edition, Pearson Publications, 1997.

4. Krishna Kant, "Microprocessor and Microcontrollers", 1st Edition, Prentice Hall of India, New Delhi, 2007.

REFERENCES:

1. A.K. Ray and K.M. Burchandi, "Intel Microprocessors Architecture Programming and Interfacing", 1st Edition, McGraw Hill, 2000.

2. Sunil Mathur, "Microprocessor 8086: Architecture, Programming and Interfacing", PHI Learning Pvt.Ltd., 5th Edition,2011.

3. Kenneth Ayala, "The 8051 Microcontroller", 3rd Edition, Delmar Cengage Learning, 2004.

4. A. NagoorKani, "Microprocessors and Microcontrollers", 1st Edition, McGraw Hill Education, 2012.

21EE213	INDUCTION AND SYNCHRONOUS MACHINES LABORATORY	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES:

- To experiment with 3 phase alternators to find voltage regulation by EMF, MMF, ZPF and ASA methods.
- To solve for direct axis reactance of salient pole alternator using slip test.
- To develop the characteristics of V and Inverted V curves in synchronous motors.
- To identify the performance characteristics of single phase and three phase induction motor.
- To build the characteristics of single phase and three phase induction motor.

LIST OF EXPERIMENTS

1. Regulation of three phase alternator by EMF and MMF methods
2. Regulation of three phase alternator by ZPF method
3. Regulation of three phase salient pole alternator by slip test
4. Measurements of negative sequence and zero sequence impedance of alternators
5. V and Inverted V curves of Three Phase Synchronous Motor
6. Load test on three-phase induction motor
7. No load and blocked rotor tests on three-phase induction motor (Determination of equivalent circuit parameters).
8. Separation of No-load losses of three-phase induction motor
9. Load test on single-phase induction motor
10. No load and blocked rotor test on single-phase induction motor
11. Harmonic Analysis of Three Phase Induction Motor
12. Study of Induction motor Starters

TOTAL: 60 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to

CO1: Experiment with 3 phase alternators to find voltage regulation by EMF, MMF, ZPF and ASA methods.

CO2: Solve for direct axis reactance of salient pole alternator using slip test.

CO3: Develop the characteristics of V and Inverted V curves in synchronous motors

CO4: Identify the performance characteristics of single phase and three phase induction motor
CO5: Construct the characteristics of single phase and three phase induction motor

21EE214	INTEGRATED CIRCUITS AND INSTRUMENTATION LABORATORY	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES:

- To model characteristics of inverting and non-inverting operational amplifier.
- To identify the performance of wave generating circuit using IC 555 timer.
- To build P, PI and PID controllers.
- To solve unknown values of R, L and C bridge using DC & AC bridge.
- To develop characteristics of transducers.

LIST OF EXPERIMENTS

1. Verify the operation of inverting and non-inverting amplifier
2. Verify the operation of adder and comparator using IC741
3. Design of integrator and differentiator using IC741
4. Design of Astable and Monostable multivibrator using NE/SE 555 timer
5. Design of P, PI & PID Controllers
6. Characteristics of Synchro Transmitter & Receiver
7. Determination of Transfer function DC Motor
8. Design of Lag, Lead & Lag-Lead Compensator
9. Measurement of unknown value of resistance, inductance and Capacitance Bridge Networks using AC and DC Bridges.
10. Identify the characteristics Dynamics of Sensors/Transducers.
    a. Pressure
    b. Displacement
11. Signal Conditioning of Analog to Digital and Digital to Analog converters.

TOTAL: 60 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to

CO1: Model adder, comparator, differentiator and integrator using IC 741.
CO2: Make use of linear ICs for verifying the function of voltage regulator, astable and mono-stable multivibrators.
CO3: Build P, PI, PID controllers and compensators.
CO4: Solve for unknown passive elements using D.C and A.C Bridges.
CO5: Develop the characteristics of energy meter, transducers and converters.

SEMESTER - V

21EE301	POWER SYSTEM ANALYSIS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To model the power system under steady state operating condition
- To utilize iterative techniques for power flow analysis
- To make use of Thevenin's theorem for symmetrical fault analysis
- To apply symmetrical components for unsymmetrical faults
- To make use of modified Euler method for stability problem in power system

UNIT I	INTRODUCTION TO POWER SYSTEM	9

Need for system planning and operational studies - Power scenario in India - Power system components - Representation - Single line diagram - per unit quantities - p.u. impedance diagram - p.u. reactance diagram - Network graph, Bus incidence matrix, Primitive parameters, Bus admittance matrix from primitive parameters - Formation of bus admittance matrix of large power network.

UNIT II	POWER FLOW ANALYSIS	9

Bus classification - Formulation of Power Flow problem in polar coordinates - Power flow solution using Gauss Seidel method - Handling of Voltage controlled buses - Power Flow Solution by Newton Raphson method

UNIT III	SYMMETRICAL FAULT ANALYSIS	9

Assumptions in short circuit analysis - Symmetrical short circuit analysis using Thevenin's theorem - Bus Impedance matrix building algorithm (without mutual coupling) - Symmetrical fault analysis through bus impedance matrix - Post fault bus voltages - Fault level - Current limiting reactors.

UNIT IV	UNSYMMETRICAL FAULT ANALYSIS	9

Symmetrical components - Sequence impedances - Sequence networks - Analysis of unsymmetrical faults at generator terminals: LG, LL and LLG - unsymmetrical fault occurringat any point in a power system - computation of post fault currents in symmetrical component and phasor domains.

UNIT V	STABILITY ANALYSIS	9

Classification of power system stability – Rotor angle stability - Swing equation - Swing curve - Power-Angle equation - Equal area criterion - Critical clearing angle and time - Classical step-by-step solution of the swing equation – modified Euler method

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Construct admittance matrix of the power system under steady state condition
CO2: Apply Gauss-Siedel and Newton Raphson techniques for power flow analysis
CO3: Utilize Thevenin's theorem for symmetrical fault analysis
CO4: Solve Line to ground fault, Line to line fault and double line to ground faults using sequence networks
CO5: Make use of equal area criterion for stability problem in power system

TEXT BOOKS:

5. Nagrath, I.J. and Kothari. D.P, "Modern Power System Analysis", 4th Edition, McGraw-

Hill Education, 2011.
6. Hadi Saadat, "Power System Analysis", 2nd Edition, Tata McGraw Hill Education, 2002.
7. John J. Grainger, William D. Stevenson. Jr, "Power System Analysis", 3rd Edition, McGraw Hill Education, 2015.
8. J. Duncan Glover, Mulukutla S.Sarma, Thomas J. Overbye, "Power System Analysis & Design", 5thEdition, Cengage Learning, 2012.

REFERENCES

5. Pai M A, "Computer Techniques in Power System Analysis", 2nd Edition, Tata McGraw-Hill Education, 2007.
6. Gupta B.R., "Power System - Analysis and Design", 6th Edition, S. Chand Publishing, 2001.
7. Kundur P., "Power System Stability and Control", 10th reprint edition, Tata McGraw Hill Education, 2010
8. Arthur Bergen, Vijay Vittal, "Power Systems Analysis ", 2nd Edition, Pearson publication, 1999.

21EE302	POWER ELECTRONICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To summarize the different types of power semiconductor devices and their switching characteristics.
- To explain the operation, characteristics and performance parameters of Phase controlled converters.
- To outline the operation, switching techniques and basics topologies of DC-DC converters.
- To relate the different modulation techniques of pulse width modulated inverters.
- To illustrate the operation of AC to AC voltage converters.

UNIT I	POWER SEMICONDUCTOR DEVICES	9

Ideal and Practical static Characteristics - Power Diodes, SCR, TRIAC, MOSFET, IGBT, GTO- Switching characteristics: SCR, MOSFET, IGBT, Driver and protection circuits - Introduction to Modern power Devices.

UNIT II	PHASECONTROLLED CONVERTERS	9

2 pulse / 3 pulse and 6 pulse converters – Effect of source inductance – performance parameters – Reactive power control of converters, Firing schemes for converter– Dual converters- Applications.

UNIT III	DC TODC CONVERTERS	9

Time ratio control and current limit control - Step-down and Step-up chopper – Switching mode regulators Buck, Boost, Buck-Boost – Introduction to Fly back Converters – concept of resonant switching- Applications.

UNIT IV	DC TO AC CONVERTERS	9

Single-phase and three-phase [120^o& 180^o mode] inverters – Voltage and harmonic control – PWM techniques – Sinusoidal PWM, Modified sinusoidal PWM and multiple PWM – Introduction to space vector modulator– current source inverter- Applications.

UNIT V	AC TO AC CONVERTERS	9
Single-phase and three-phase AC voltage controllers – Multistage sequence control – single phase and three phase cyclo-converters– Introduction to Matrix converters-Application.		
		TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Summarize the types of power semiconductor switches.
CO2: Explain the performance parameters of Phase controlled converters.
CO3: Relate the working of various types of DC to DC converters.
CO4: Outline the concept of different PWM techniques.
CO5: Demonstrate the control of AC to AC converters.

TEXT BOOKS:

1. Rashid M.H., "Power Electronics Circuits, Devices and Applications", 3rd Edition, Prentice Hall India, New Delhi, 2004.
2. Ned Mohan, T.M.Undeland, W.P.Robbins, "Power Electronics: Converters, applications and design", 3rd Edition, John wiley and Sons, 2006.
3. P.S.Bimbra, "Power Electronics", 3rd Edition, Khanna Publishers, 2003
4. M.D. Singh and K.B. Khanchandani, "Power Electronics," Mc Graw Hill India, 1st Edition 2013.

REFERENCES

1. Cyril.W.Lander, "Power Electronics", 3rd Edition, McGraw Hill International, 1993.
2. Bimal K.Bose. "Modern Power Electronics and AC Drives", 1st Edition Pearson Education, 2002.
3. Philip T.Krein, "Elements of Power Electronics", 1st Edition, Oxford University Press, 2004.
4. Joseph Vithayathi, "Power electronics Principles and application", McGraw Hill series 6th Edition, 2013.

21EE303	DIGITAL SIGNAL PROCESSING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To illustrate the concepts of Signals and systems & their mathematical representation.
- To outline the discrete time systems.
- To demonstrate the transformation techniques & their computation.
- To explain filters and their design for digital implementation.
- To summarize programmability digital signal processor & quantization effects.

UNIT I	INTRODUCTION	9
Classification of systems: Continuous, discrete, linear, causal, stability, dynamic, recursive, time variance; classification of signals: continuous and discrete, energy and power; mathematical representation of signals; spectral density; sampling techniques, quantization, quantization error, Nyquist rate, aliasing effect.		
UNIT II	**DISCRETE TIME SYSTEM ANALYSIS**	**9**
Z-transform and its properties, inverse z-transforms; difference equation – Solution by z-transform, application to discrete systems – Stability analysis, frequency response – Convolution		

– Discrete Time Fourier transform ,magnitude and phase representation		
UNIT III	**DISCRETE FOURIER TRANSFORM AND COMPUTATION**	**9**
Discrete Fourier Transform- Properties, magnitude and phase representation – Computation of DFT using FFT algorithm – DIT &DIF using radix 2 FFT – Butterfly structure		
UNIT IV	**DIGITAL SIGNAL PROCESSORS**	**9**
Introduction – Architecture – Features – Addressing Formats – Functional modes – Introduction to Commercial DS Processors.		
UNIT V	**APPLICATIONS OF DIGITAL SIGNAL PROCESSING**	**9**
Introduction-Applications of DSP in Biomedical Engineering-Voice Processing-Applications to RADAR-Applications to image processing-Introduction to wavelets-Wireless Communication.		
		TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1. Explain the importance of Fourier transform, digital filters and DS Processors.
CO2. Summarize the knowledge on Signals and systems & their mathematical representation.
CO3. Illustrate the transformation techniques and their computation.
CO4. Compare the types of filters and their design for digital implementation.
CO5. Outline the various applications of digital signal processing

TEXT BOOKS:

1. J.G. Proakis and D.G. Manolakis, "Digital Signal Processing Principles, Algorithms and Applications", 1st Edition, Pearson Education, New Delhi, PHI. 2003.
2. S.K. Mitra, "Digital Signal Processing – A Computer Based Approach", 1st Edition, McGraw Hill Edu, 2013.
3. Lonnie C.Ludeman ,"Fundamentals of Digital Signal Processing", 1st Edition, Wiley,2013.
4. Robert Schilling & Sandra L.Harris, Introduction to Digital Signal Processing using Matlab", 1st Edition, Cengage Learning,2014

REFERENCES

1. Poorna Chandra S, Sasikala. B , "Digital Signal Processing" , 1st Edition, Tata Mc Graw Hill ,2013.
2. B.P.Lathi, "Principles of Signal Processing and Linear Systems", 1st Edition, Oxford University Press, 2010.
3. Taan S. ElAli, "Discrete Systems and Digital Signal Processing with Mat Lab", 1st Edition, CRC Press, 2009.
4. SenM.kuo, woonsenggan, "Digital Signal Processors, Architecture, Implementations & Applications", 1st Edition, Pearson, 2013.
5. DimitrisG.Manolakis, Vinay K. Ingle, "Applied Digital Signal Processing" , 1st Edition, Cambridge, 2012.

21EE304	**EMBEDDED SYSTEMS (Theory with Practical Course)**	**L**	**T**	**P**	**C**
		2	**0**	**2**	**3**

COURSE OBJECTIVES:

- To explain the building blocks of embedded system.
- To illustrate the interfacing of embedded network.
- To summarize the various embedded development strategies

- To develop the programs to interface memory, I/Os with processor.
- To build the embedded system blocks for simple applications

UNIT I	INTRODUCTION TO EMBEDDED SYSTEMS	6

Introduction to Embedded Systems –Structural units in Embedded Processor, selection of processor & memory devices- DMA — Memory management methods- Timer and Counting devices.

UNIT II	EMBEDDED NETWORKING	6

Embedded Networking: Introduction, I/O Device Ports & Buses–CAN Bus -Serial Peripheral Interface (SPI) — Inter Integrated Circuits (I2C) –need for device drivers.

UNIT III	EMBEDDED FIRMWARE DEVELOPMENT ENVIRONMENT	6

Embedded Product Development Life Cycle- objectives, different phases of EDLC, Modelling of EDLC; issues in Hardware-software Co-design.

UNIT IV	RTOS BASED EMBEDDED SYSTEM DESIGN	6

Introduction to basic concepts of RTOS- Task, process & threads, interrupt routines in RTOS, Multiprocessing and Multitasking, Preemptive and non-preemptive scheduling, Task communication shared memory, message passing-, Inter process Communication.

UNIT V	EMBEDDED SYSTEM APPLICATION AND DEVELOPMENT	6

Case Study of Washing Machine- Automotive Application- Smart card System Application- ATM machine –Digital camera.

TOTAL:30 PERIODS

PRACTICAL COURSE	15

LIST OF EXPERIMENTS

1. Interfacing ADC and DAC.
2. Interfacing real time clock and serial port.
3. Interfacing EPROM and interrupt.
4. Interrupt performance characteristics of ARM and FPGA.
5. Implementing Zigbee protocol with ARM.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Outline the concepts of embedded systems.
CO2: Demonstrate the embedded networking for bus communication.
CO3: Illustrate the various Embedded firmware development.
CO4: Apply the programs to interface memory, I/Os with processor.
CO5: Develop the embedded system blocks for simple applications

TEXT BOOKS:

1. Rajkamal, "Embedded System-Architecture, Programming, Design", 2nd Edition,Mc Graw Hill, 2013.
2. Peckol, "Embedded system Design", 1st Edition, John Wiley & Sons, 2010.
3. Karim Yaghmour, Jon Masters, Gilad Ben-Yossef, and Philippe Gerum, "Building Embedded Linux Systems" 2nd Edition, SPD -O'Reilly Publications, 2008.
4. C.M. Krishna, Kang, G.Shin, "Real Time Systems", 3rdEdition, McGraw Hill, 1997.

REFERENCES

1. Shibu. K.V, "Introduction to Embedded Systems", 1st Edition,Tata Mcgraw Hill,2009.
2. Han-Way Huang, "Embedded system Design Using C8051", 2nd Edition,Cengage Learning,2009.
3. Jan Axelson "Embedded Ethernet and Internet Complete", 2nd Edition, Penram publications, 2003.
4. Bhaskar Krishnamachari, "Networking wireless sensors", 1st Edition, Cambridge press, 2005.

21CS308	C AND DATA STRUCTURES	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES:

- To explain the concepts of C programming using arrays.
- To describe the concepts of function and structure for problem solving.
- To make use of the concept List, Stack, Queues ADTs.
- To illustrate Tree and Graph data structure for solving real time problems
- To choose different searching and sorting algorithms.

UNIT-I	INTRODUCTION TO C	9

Structure of C Program-Pre-processor Directives-Compilation and Linking Processes-Data types-Storage classes-Constants-Variables-Operators-Expressions-Input/output Statements--Arrays: Declaration-Initilization-1-Dimensional Array-Two Dimensional Arrays.

Suggested Activities:

- Practice of C programming using statements, expressions, decision making and iterative statements
- Practice of C programming using Arrays

UNIT-II	FUNCTIONS, POINTERS AND STRUCTURES	9

Functions: Pass by value-Pass by reference and Recursion-Pointer definition-Initialization-pointer arithmetic-Structures-Definition-Structure with Structure-Programs using structures

Suggested Activities:

- Call by value & Call by reference
- Passing Structure Members as arguments to Function
- Implement C programs using Pointers and Structures

UNIT-III	LINEAR DATA STRUCTURES	9

Abstract Data Type(ADT)-Stacks ADT and Queues ADT -Array- based Implementation-Linked List-Linked List based Implementation of stack and queues-Evaluation of Expression-Linked list based Polynomial Addition.

Suggested Activities:

- Array implementation of List ADT
- Array implementation of Stack and Queue ADTs
- Linked list implementation of List, Stack and Queue ADTs
- Applications of List, Stack and Queue ADTs

UNIT-IV	NON LINEAR DATA STRUCTURE	9

Trees - Binary trees - Binary tree representation and traversals - Binary Search Tree Applications of trees. Graph - Definitions - Representations - Breadth first traversal - Depth first traversal

Suggested Activities:

- Implementation of Binary Trees and operations of Binary Trees
- Implementation of Binary Search Trees

UNIT-V	SEARCHING AND SORTING ALGORITHMS	9

Liner Search-Binary Search- Bubble sort –Insertion Search-Merge sort-Quick Sort-Hash Tables-Overflow Handling.

- Implementation of searching techniques
- Implementation of Sorting algorithms : Insertion Sort, Quick Sort, Merge Sort
- Implementation of Hashing – any two collision techniques

TOTAL:45 PERIODS

COURSE OUTCOMES: At end of the course, learners will be able to:

CO1: Develop C programs for simple applications using basic constructs and arrays.
CO2: Construct C programs involving functions, recursion, pointers & structures.
CO3: Build abstract data types for linear data structures.
CO4: Categorize the different non-linear data structures to resolve problems.
CO5: Solve the problems using various sorting algorithms and hashing techniques.

TEXT BOOKS:

1. ReemaThareja, "Programming in C", 2nd Edition,Oxford University Press, 2016.
2. ReemaThareja, "Data Structures Using C", Second Edition , Oxford University Press, 2011
3. Ellis Horowitz, SartajSahni and Sanguthevar Rajasekaran, "Fundamentals of Computer Algorithms", 2nd Edition, Universities Press, 2011.

REFERENCES:

1. Paul Deitel and Harvey Deitel, "C How to Program with an Introduction to C++", Eighth edition, Pearson Education, 2018.
2. Yashwant Kanetkar, "Let us C", 17th Edition, BPB Publications, 2020.
3. Mark Allen Weiss,"Data Structures and Algorithm Analysis in C", 2nd Edition, Pearson Education, 2010.

21EE305	POWER ELECTRONICS LABORATORY	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES:

- To demonstrate the performance and characteristics of power semiconductor devices, converters and inverters
- To experiment with the characteristics of different power switching devices.
- To analyze the operation of AC/DC fully and half controlled converters
- To apply the chopper circuits in switching devices.
- To identify the output of inverters for different duty cycle

LIST OF EXPERIMENTS

1. Characteristics of SCR and TRIAC
2. Characteristics of MOSFET and IGBT
3. Characteristics of GTO

4. AC to DC fully controlled converter
5. AC to DC half-controlled converter
6. Step down and step up MOSFET based choppers
7. IGBT based single-phase PWM inverter
8. IGBT based three-phase PWM inverter
9. Resonant DC-to-DC converter
10. Permanent magnet brushless BLDC motor
11. Simulation of Power electronic circuits (Single phase three phase -semi converter, full converter, DC-DC converters, AC volt controller.)
12. Study of battery charger, UPS and SMPS.

TOTAL: 60 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Experiment with the characteristics curves of different switching devices.
CO2: Make use of power devices for AC/DC fully and half controlled converter design.
CO3:Analyze the operation of switching devices in chopper circuits
CO4:Identify the output of inverters for different duty cycle
CO5:Apply suitable simulation tool for power electronic circuits

21EN301	PROFESSIONAL COMMUNICATION LABORATORY (Common to all B.E./B.Tech. Programmes)	L	T	P	C
		0	0	2	1

COURSE OBJECTIVES:

- To demonstrate communication skills that can lead to improved interpersonal relationships.
- To plan to set and achieve goals with focus.
- To organize themselves in work life to face the professional set up with confidence.
- To interpret ideas and participate in group discussion with positive attitude.
- To develop their confidence and help learners to attend interviews successfully.

UNIT I	**COMMUNICATION AND PROFESSIONAL ETIQUETTES**	**6**
Importance and Types of Communication Verbal communication -Presentation skills- Non-Verbal communication - Personal Appearance, Posture, Gestures, Facial Expressions, Eye Contact and Space Distancing - Professional Etiquette		
UNIT II	**GOAL SETTING AND MOTIVATION**	**6**
Short term and Long term Goals- Strategies to set and achieve goals- Motivation		
UNIT III	**TIME AND STRESS MANAGEMENT**	**6**
Importance of Time - Time Management Skills - Sources of Stress - Managing Stress - Analysis of the Case Studies on time and stress management		
UNIT IV	**GROUP DISCUSSIONS AND POSITIVE ATTITUDE**	**6**
Group Discussions - Leadership Qualities - Decision Making - Problem Solving - Negotiation Skills - Positive Attitude		
UNIT V	**RESUME MAKING AND INTERVIEW SKILLS**	**6**
Preparing Resume - E - Resume - Covering Letter – Job Application through email - Career Portfolio - Types of Interviews - Mock Interviews		
	TOTAL: 30 PERIODS	

COURSE OUTCOMES: **At the end of the course, learners will be able to:**

CO1: Demonstrate effective communication skills through presentations.
CO2: Utilize their knowledge of motivation in setting and achieving goals.
CO3: Examine time and stress management.
CO4: Formulate their ideas into an effective communication in formal contexts.
CO5: Develop a well-composed resume and face interviews confidently.

TEXTBOOKS:

1. Dhanavel S P, "English and Soft Skills", First Edition , Orient BlackSwan Ltd, Hyderabad : 2012.
2. Dr. Tobin Porterfield & Bob Graham ,"The 55 Soft Skills That Guide Employee and Organizational Success," Mason – West Publishing House , (January 4, 2018)
3. Prashant Sharma, "Soft Skills Personality Development for Life Success, " BPB Publications, New Delhi, January 2018.

REFERENCES:

1. M. Ashraf Rizvi, "Effective Technical Communication," Tata McGraw Hill Education Pvt. Ltd. New Delhi, 2016.
2. Mohan Krishna & Meera Banerji, "Developing Communication Skills," First Edition, Trinity Press, 2017.
3. N. Krishnaswami& T. Sriraman, "Creative English for Communication," Third Edition, Laxmi Publications Private Limited, 2017.

SEMESTER-VI

21EE306	PROTECTION AND SWITCHGEAR	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To summarize the causes of abnormal operating conditions such as faults, lightning and switching surges of the power apparatus
- To infer the characteristics and functions of relays and protection schemes.
- To explain about the apparatus protection of generators, transformers and motors.
- To outline the static and numerical relays
- To illustrate the different types of circuit breakers.

UNIT I	PROTECTION SCHEMES	9

Principles and need for protective schemes – nature and causes of faults – types of faults –Effects of faults– Methods of Grounding - Zones of protection and essential qualities of protection – Protection scheme.

UNIT II	ELECTROMAGNETIC RELAYS	9

Operating principles of relays - Universal relay – Torque equation – R-X diagram – Electromagnetic Relays – Over current, Directional, Distance, Differential, Negative sequence and Under frequency relays

UNIT III	APPARATUS PROTECTION	9

Current transformers and Potential transformers and their applications in protection schemes - Protection of transformer –differential protection, protection against overheating, magnetising inrush current , Buchholz Relay - generator, motor, bus bars and transmission line.

UNIT IV	STATIC RELAYS AND NUMERICAL PROTECTION	9

Static relays – Phase, Amplitude Comparators – Synthesis of various relays using Static comparators – Block diagram of Numerical relays – Over current protection, transformer differential protection, distant protection of transmission lines.

UNIT V	CIRCUIT BREAKERS	9

Physics of arcing phenomenon and arc interruption - DC and AC circuit breaking – re-striking voltage and recovery voltage - rate of rise of recovery voltage - resistance switching - current chopping - interruption of capacitive current - Types of circuit breakers – air blast, air break, oil, SF6, MCBs, MCCBs and vacuum circuit breakers – comparison of different circuit breakers – Rating and selection of Circuit breakers.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Summarize Electromagnetic and Static Relays.
CO2: Explain the causes of abnormal operating conditions of the apparatus and system
CO3: Outline the characteristics and functions of relays and protection schemes
CO4: Illustrate the apparatus protection, static and numerical relays
CO5: Interpret the knowledge on functioning and suitability of circuit breaker.

TEXT BOOKS:

1. Sunil S.Rao, "Switchgear and Protection", 1st Edition, Khanna Publishers, New Delhi, 2008.
2. B.Rabindranath and N.Chander, "Power System Protection and Switchgear", 1st Edition,

New Age International (P) Ltd., 2011.
3. BadriRam,B.H. Vishwakarma, "Power System Protection and Switchgear", 2nd Edition, New Age International Pvt Ltd Publishers, 2011.
4. Y.G.Paithankar and S.R.Bhide, 'Fundamentals of power system protection', 2nd Edition, Prentice Hall of India Pvt. Ltd., New Delhi, 2010.

REFERENCES:

1. C.L.Wadhwa, "Electrical Power Systems", 6th Edition, New Age International (P) Ltd., 2010
2. Ravindra P.Singh, 'Switchgear and Power System Protection', 1st Edition, PHI Learning Private Ltd., NewDelhi, 2009.
3. Rohit Metha and VK Metha, "Principles of Power Systems" 1st Edition, S.Chand Publishers, 2005.
4. S.L.Uppal, "Electrical Power"1st Edition, Khanna Publishers, 1985.

21EE307	RENEWABLE ENERGY SYSTEMS (Theory with Practical Course)	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES:

- To explain the various renewable energy sources
- To illustrate the working principle of wind power plants
- To summarize the various types of solar thermal and solar PV systems
- To interpret the biomass conversion and mini/micro hydro power plant.
- To experiment with the characteristics of solar, wind and hybrid and energy generation.

UNIT I	RENEWABLE ENERGY (RE) SOURCES	6

Environmental consequences of fossil fuel use, Importance of renewable sources of energy, Sustainable Design and development, Types of RE sources, Limitations of RE sources, Present Indian and international energy scenario of conventional and RE sources.

UNIT II	WIND ENERGY	6

Power in the Wind – Types of Wind Power Plants(WPPs)–Components of WPPs-Working of WPPs- Siting of WPPs-Grid integration issues of WPPs.

UNIT III	SOLAR PV AND THERMAL SYSTEMS	6

Solar Radiation, Radiation Measurement, Solar Thermal Power Plant, Central Receiver Power Plants, Solar Ponds.- Thermal Energy storage system with PCM- Solar Photovoltaic systems : Basic Principle of SPV conversion – Types of PV Systems- Types of Solar Cells, Photovoltaic cell concepts: Cell, module, array ,PV Module I-V Characteristics, Efficiency & Quality of the Cell, series and parallel connections, maximum power point tracking, Applications.

UNIT IV	BIOMASS ENERGY	6

Introduction-Bio mass resources –Energy from Bio mass: conversion processes-Biomass Cogeneration-Environmental Benefits. Mini/micro hydro power: Classification of hydropower schemes, Essential components of hydroelectric system.

UNIT V	OTHER ENERGY SOURCES	6

Tidal Energy: Energy from the tides, Barrage and Non Barrage Tidal power systems. Ocean Thermal Energy Conversion (OTEC)- Fuel cell : Principle of working- various types - construction and applications. Energy Storage System- Hybrid Energy Systems.

	TOTAL: 30 PERIODS
PRACTICAL COURSE	**15**

LIST OF EXPERIMENTS

1. Experiment on "V-I Characteristics and Efficiency of 1KWp Solar PV System".
2. Experiment on "Shadowing effect & diode based solution in 1KWp Solar PV System".
3. Experiment on Performance assessment of Grid connected and Standalone 1KWp Solar Power System.
4. Experiment the relationship between the tip speed ratio and power coefficient of the turbine at different wind speed
5. Experiment on Performance Assessment of Hybrid (Solar-Wind) Power System.

TOTAL: 45 PERIODS

OUTCOMES: At the end of the course, learners will be able to:

CO1: Summarize various renewable energy sources and technologies
CO2: Illustrate the wind power plant working principle
CO3: Outline the solar PV and solar thermal power plant and its types
CO4: Explain the hydro power plant and biomass conversion
CO5: Experiment with the performance and characteristics of solar, wind and hybrid energy generation.

TEXT BOOKS:

1. Joshua Earnest, Tore Wizeliu, 'Wind Power Plants and Project Development', 1st Edition PHI Learning Pvt. Ltd, New Delhi, 2011.
2. D.P.Kothari, K.C Singal, Rakesh Ranjan "Renewable Energy Sources and Emerging Technologies", 2nd Edition PHI Learning Pvt. Ltd, New Delhi, 2013.
3. Scott Grinnell, "Renewable Energy & Sustainable Design", 1st Edition CENGAGE Learning, USA, 2016.
4. Chetan Singh Solanki, "Solar Photovoltaics: Fundamentals, Technologies and Applications", 2nd Edition PHI Learning Private Limited, New Delhi, 2011.

REFERENCES

1. A.K.Mukerjee and Nivedita Thakur," Photovoltaic Systems: Analysis and Design", 2nd Edition PHI Learning Private Limited, New Delhi, 2011
2. Richard A. Dunlap," Sustainable Energy" 1st Edition Cengage Learning India Private Limited, Delhi, 2015.
3. Godfrey Boyle, "Renewable energy", Open University, 2nd Edition Oxford University Press in association with the Open University, 2004.
4. A.Shunmugalatha, M.Devaki and R.Saranya, Renewable Energy Systems, 1st Edition Technical publication, 2020.

21EE308	ELECTRICAL DRIVES LABORATORY	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES:

- To outline the characteristics of MPPT DC-DC boost Converter and Bi Directional Battery Charger.
- To develop the characteristics of 3 Phase Thyristorized Drive for DC Motor
- To model the DC Motor using digital simulation.

- To construct the speed control of the synchronous motor drive using simulation

LIST OF EXPERIMENTS

1. 3 ϕ Inverter With MPPT DC-DC boost Converter
2. 3 Phase Thyristorized Drive for DC Motor
3. Closed Loop Control of Chopper Fed DC Motor Drive
4. Embedded Control of Slip Ring Induction Motor Using Static Krammer Drive
5. Speed Control of Single Phase Induction Motor Drive Using 3 Phase to Single Phase Matrix Converter
6. Speed Control of Brushless Dc Drive
7. Embedded Control of Switched Reluctance Motor Drive
8. PLC Based Four Quadrant Operation Of 3 Phase Squirrel Cage Induction Motor Drive
9. Speed Control of 3 Phase Multilevel Inverter Fed Squirrel Cage Induction Motor Drive
10. Simulation of speed control of the synchronous motor drive.
11. Simulation of starting of DC motor
12. BLDC motor drive using digital simulation

TOTAL: 60 PERIODS

COURES OUTCOMES: At the end of the course, learners will be able to:

CO1: Develop 3 ϕ Inverter With MPPT DC-DC boost Converter.

CO2: Identify the characteristics of 3 Phase Thyristorized Drive for DC Motor

CO3:Model the performance characteristics of DC Motor using digital simulation

CO4: construct the speed control of the synchronous motor drive using simulation

CO5: Make use of BLDC motor drive using digital simulation

SEMESTER-VII

21EE401	POWER SYSTEM OPERATION AND CONTROL	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To apply the concepts of power system operation and control with its cost parameters.
- To illustrate about Real power-frequency interaction
- To explain the concept of Reactive power-voltage control and actions to be implemented.
- To solve the problems related to Economic operation of power system.
- To outline the role of computer for real time operation and control of power systems.

UNIT I	INTRODUCTION	9

Electricity regions in India - Indian Power Exchanges – National and Regional load dispatching centers –requirements of good power system - necessity of voltage and frequency regulation – real Power vs frequency and reactive power Vs voltage control loops - Load curve, load duration curve, Load distribution parameters, relative merits & demerits, Capital & Operating Cost of different power plants, Power tariff types, load forecasting, Site selection criteria- basic concepts of load dispatching.

UNIT II	REAL POWER - FREQUENCY CONTROL	9

Basics of speed governing mechanisms and modeling - speed load characteristics - regulation of two generators in parallel-Load Frequency Control (LFC) of single area system-static and dynamic analysis of uncontrolled and controlled cases - LFC of two area system - tie line modeling – block diagram representation of two area system - tie line with frequency bias control – state variable model - integration of economic dispatch control with LFC.

UNIT III	REACTIVE POWER – VOLTAGE CONTROL	9

Generation and absorption of reactive power - basics of reactive power control – Automatic Voltage Regulator (AVR) – brushless AC excitation system – block diagram representation of AVR loop - static and dynamic analysis – stability compensation – voltage drop in transmission line - methods of reactive power injection - tap changing transformer, SVC (TCR + TSC) and STATCOM for voltage control

UNIT IV	ECONOMIC OPERATION OF POWER SYSTEM	9

Statement of economic dispatch problem - input and output characteristics of thermal plant - incremental cost curve - optimal operation of thermal units without and with transmission losses (no derivation of transmission loss coefficients) - base point and participation factors method - statement of unit commitment (UC) problem - constraints on UC problem – solution of UC problem using priority list.

UNIT V	COMPUTER CONTROL OF POWER SYSTEMS	9

Need of computer control of power systems-concept of energy control centers and functions – PMU - system monitoring, data acquisition and controls - System hardware configurations - SCADA and EMS functions - state estimation problem – measurements and errors - weighted least square estimation - various operating states - state transition diagram.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Build the various power system operation problems for different loading conditions

CO2: Illustrate the need and importance of load frequency control.

CO3: Explain the various control actions for maintaining the voltage profile under dynamic loading conditions.
CO4: Solve the optimum scheduling and cost of generators using economic dispatch and unit commitment concepts.
CO5: Explain the various control actions for monitoring the Power system security.

TEXT BOOKS:

1. Olle. I.Elgerd, "Electric Energy Systems theory - An introduction", 34th Reprint, McGraw Hill Education Pvt. Ltd., New Delhi, 2010.
2. Allen. J. Wood and Bruce F. Wollen berg, "Power Generation, Operation and Control", 1st Edition, John Wiley & Sons, Inc., 2016.
3. Abhijit Chakrabarti and Sunita Halder, "Power System Analysis Operation and Control", 3rd Edition, PHI learning Pvt. Ltd., New Delhi, 2010.
4. K Uma Rao, "Power system operation and control", 1st Edition, Wiley-India, 2013.

REFERENCES:

1. Kothari D.P. and Nagrath I.J., "Power System Engineering", 2nd Edition, Tata McGraw-Hill Education, 2008.
2. Hadi Saadat, "Power System Analysis", 21st reprint, McGraw Hill Education Pvt. Ltd., New Delhi, 2010.
3. Kundur P., "Power System Stability and Control", 10th reprint, McGraw Hill Education Pvt. Ltd.,New Delhi, 2010.
4. S.Sivanagaraju, "Power Generation, Operation and Control", 1st Edition, Pearson Education India, 2009.

21EE402	POWER SYSTEM LABORATORY	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES:

- To demonstrate transmission line parameters
- To develop the network matrices for the load flow and fault analysis
- To apply Gauss-Seidal (GS) method and Newton-Raphson (NR) method for power flow problems
- To solve small signal stability problems by fault analysis in power system
- To experiment with load frequency load frequency dynamics and electromagnetic transients

LIST OF EXPERIMENTS

1. Computation of ABCD Parameters.
2. Computation of transmission efficiency and voltage regulation.
3. Y bus formation and Z bus.
4. Load Flow Analysis- I: Solution of load flow and related problems using Gauss-Seidel Method.
5. Load Flow Analysis- II: Solution of load flow and related problems using Newton Raphson.
6. Fault Analysis.
7. Transient and Small Signal Stability Analysis: Single-Machine Infinite Bus System.
8. Transient Stability Analysis of Multimachine Power Systems.
9. Electromagnetic Transients in Power Systems.
10. Economic Dispatch in Power Systems.

11. Load–Frequency Dynamics of Single- Area and Two-Area Power Systems.
12. Application of Neural Network in Power System.

TOTAL: 60 PERIODS

COURES OUTCOMES: At the end of the course, learners will be able to:

CO1:Model transmission line parameters
CO2: Develop the network matrices for the load flow and fault analysis
CO3: Solve for power flow using GS and NR method
CO4: Solve the small signal and transient stability problems during fault from the network matrix
CO5: Solve the load frequency dynamics and electromagnetic transient problems

21EE403	PROJECT WORK I	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES:

- To identify the problems in industries and social relevant applications.
- To make use of innovative methods for problem identification.
- To develop the prototype for the project.
- To apply the real time for successful working.
- To identify the platforms for the project explorations.

METHOD OF EVALUATION:

- The students in a group of 3 to 4 works on a topic approved by the head of the department and prepare a comprehensive project-I report after completing the work.
- The progress of the project is evaluated based on a minimum of two reviews. The review committee may be constituted by the Head of the Department.
- A project report is required at the end of the semester.
- The project work is evaluated based on oral presentation and the project report jointly by external and internal examiners constituted by the Head of the Department.

TOTAL: 60PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Outline the problem identified in industries.
CO2: Experiment with the innovative techniques.
CO3: Make use of advanced tools for the solution.
CO4: Select a suitable method for implementation.
CO5: Analyse the developed prototype for future scope.

SEMESTER-VIII

21EE404	PROJECT WORK II	L	T	P	C
		0	0	20	10

COURSE OBJECTIVES:

- To organize the works related to project.
- To solve a specific problem right from its identification and literature review till the successful solution of the same.
- To develop the students in preparing project reports.
- To build the students to face reviews and viva voce examination.
- To plan project contest and journal publication.

METHOD OF EVALUATION:

- The students in a group of 3 to 4 works on a topic approved by the review committee under the guidance of the HoD and prepare a comprehensive project report after completing the work to the satisfaction of the supervisor.
- The progress of the project is evaluated based on minimum of three reviews.
- A project report is required at the end of the semester.
- The project work is evaluated based on oral presentation, hardware/software results and the project report jointly by external and internal examiners.

TOTAL: 300 PERIODS

COURSE OUTCOMES: At the end of the course, the students will be able to:

CO1: Solve engineering problem with social relevance.
CO2: Plan for writing report and viva voce examination.
CO3: Make use of the project reports for publications.
CO4: Choose a suitable methodology for a problem solving.
CO5**:** Organize the works related to project implementation.

PROFESSIONAL ELECTIVE COURSES: VERTICALS
VERTICAL I: POWER ENGINEERING

21PEE01	ENERGY UTILIZATION AND CONSERVATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To illustrate the energy saving concept by different ways of illumination.
- To explain the basics of Refrigeration and Air conditioning
- To outline the concepts of heating & welding
- To explain the concepts of electric traction systems and their performance
- To summarize the various energy conservation Act and Policy

UNIT I	ILLUMINATION	9

Introduction - definition and meaning of terms used in illumination engineering - classification and comparison of light sources – (incandescent lamps, sodium vapour lamps, mercury vapour lamps, fluorescent lamps)– design of illumination systems - indoor lighting schemes - factory lighting halls - outdoor lighting schemes - flood lighting - street lighting - energy saving lamps, LED. Design of Illumination system - Case Studies

UNIT II	REFRIGERATION AND AIR CONDITIONING	9

Refrigeration-Domestic refrigerator and water coolers - Air-Conditioning-Various types of air-conditioning system and their applications, smart air conditioning units - Energy Efficient motors: Standard motor efficiency, need for efficient motors, Motor life cycle, Direct Savings and payback analysis, efficiency evaluation factor.

UNIT III	HEATING AND WELDING	9

Introduction - advantages of electric heating – modes of heat transfer - methods of electric heating - resistance heating - arc furnaces - induction heating - dielectric heating - electric welding – types - resistance welding - arc welding - power supply for arc welding - radiation welding.- Induction Welding

UNIT IV	ELECTRIC DRIVES AND TRACTION	9

Fundamentals of electric drive - choice of an electric motor - application of motors for particular services - traction motors - characteristic features of traction motor - systems of railway electrification - electric braking - train movement and energy consumption - traction motor control - track equipment and collection gear.

UNIT V	ENERGY CONSERVATION ACT,2001 AND RELATED POLICIES	9

Energy Conservation Act-2001 and its features –Notification under the Act Schemes of Bureau of Energy efficiency (BEE)-ECBC,S&L,DSM,BLY,SME'S, Designated Agencies-Electricity Act 2003-Integrated Energy Policy-National Action Plan change on climate change

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Compare different illumination schemes

CO2: Outline the concepts of Refrigeration and Air conditioning

CO3: Summarize various modes of heating and Welding with its applications.

CO4: Illustrate the choice of electric drives and the different characteristics of motor for traction

CO5: Explain the various energy conservation methods

TEXT BOOKS:

1. Wadhwa, C.L. "Generation, Distribution and Utilization of Electrical Energy", 1st Edition, New Age International Pvt. Ltd, 2003.
2. Dr. Uppal S.L. and Prof. S. Rao, "Electrical Power Systems", 15th Edition, Khanna Publishers, New Delhi, 2014.
3. "General Aspects of Energy Management and Auditing", BEE Guide Book, 2010
4. Y P Abbi and Shashank Jain, "Handbook on Energy Audit and Environment Management " 1st Edition, The Energy and Resources Institute (TERI), 2006

REFERENCES:

1. Partab.H, "Art and Science of Utilisation of Electrical Energy", 1st Edition, DhanpatRai and Co, New Delhi, 2004.
2. Gupta.J.B, "Utilization of Electric Power and Electric Traction", 1st Edition, S.K.Kataria and Sons, 2002.
3. "Cleaner Production – Energy Efficiency Manual for GERIAP", UNEP, Bangkok prepared by National Productivity Council.
4. David H Phillips, "Welding Engineering An Introduction" , 1st Edition, John Wiley & Sons Ltd.,2016.

21PEE02	SMART GRID	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To explain the concepts of smart Grid in detail.
- To illustrate about the smart grid technologies.
- To outline about Smart Meters and Advanced Metering Infrastructure.
- To infer the power quality management issues in Smart Grid.
- To summarize the performance computing in Smart Grid applications.

UNIT I	INTRODUCTION TO SMART GRID	9

Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid - Smart grid drivers, functions, opportunities, challenges and benefits, Difference between conventional & Smart Grid - National and International Initiatives in Smart Grid.

UNIT II	SMART GRID TECHNOLOGIES	9

Technology Drivers, Smart energy resources, Smart substations, Substation Automation, Feeder Automation, Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and control, Distribution systems: DMS, Volt/VAR control, Fault Detection, Isolation and service restoration, Outage management, High-Efficiency Distribution Transformers, Phase Shifting Transformers, Plugin Hybrid Electric Vehicles(PHEV).

UNIT III	SMART METERS AND ADVANCED METERING INFRASTRUCTURE	9

Introduction to Smart Meters- ,Advanced Metering infrastructure(AMI)drivers and benefits, AMI protocols,- - standards and initiatives,- AMI needs in the smart grid, - Phasor Measurement Unit(PMU), Intelligent Electronic Devices(IED)&their application for monitoring & protection.

UNIT IV	POWER QUALITY MANAGEMENT IN SMART GRID	9

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.

UNIT V	HIGH PERFORMANCE COMPUTING FOR SMART GRID APPLICATIONS	9

Local Area Network(LAN),House Area Network(HAN), Wide Area Network(WAN), Broadband over Power line(BPL),IP based Protocols, Basics of Web Service and CLOUD Computing to make Smart Grids smarter, Cyber Security for Smart Grid.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Relate the concepts of Smart Grid and its present developments.
CO2: Outline different Smart Grid technologies.
CO3: Summarize different smart meters and advanced metering infrastructure.
CO4: Illustrate power quality management in Smart Grids
CO5: Explain LAN, WAN and Cloud Computing for Smart Grid application

TEXT BOOKS:

1. Stuart Borlase "Smart Grid: Infrastructure, Technology and Solutions", 1st Edition, CRC Press 2012.
2. Janaka Ekanayake, Nick Jenkins, KithsiriLiyanage, JianzhongWu, Akihiko Yokoyama, "Smart Grid: Technology and Applications", 1st Edition, Wiley 2012.
3. Salman K. Salman, "Introduction to the Smart Grid: Concepts, technologies and evolution", 1st Edition, Institution of Engineering and Technology (IET), 2017.
4. Bernd M. Buchholz, Zbigniew A. Styczynski , "Smart Grids: Fundamentals and Technologies in Electric Power Systems of the Future", 1st Edition, Springer, 2020.

REFERENCES:

1. Xi Fang, SatyajayantMisra, GuoliangXue, and Dejun Yang "SmartGrid –The New and Improved Power Grid: A Survey", IEEE Transaction on Smart Grids, vol.14,2012
2. James Momohe "Smart Grid: Fundamentals of Design and Analysis," 1st Edition, Wiley-IEEE Press, 2012.
3. Dr. A. Shunmugalatha,, Dr. S. Senthilrani,,Dr. T. Chandrasekar and Mrs. J. Rajeswari, "Smart Grid", 1st Edition, Technical Publications, 2020.
4. Vehbi C. Güngör ,Dilan Sahin, Taskin Kocak, Salih Ergüt, Concettina Buccella, Carlo Cecati, and Gerhard P. Hancke, "Smart Grid Technologies: Communication Technologies and Standards" IEEE Transactions On Industrial Informatics, Vol.7,No.4, November 2011.

21PEE03	POWER QUALITY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To illustrate various sources, causes and effects of power quality issues.
- To summarize the causes and mitigation techniques of voltage sag & swell.
- To outline the concepts of harmonics, voltage and current distortions.
- To interpret the knowledge on compensation techniques and design the passive filters.
- To explain the concepts of power quality monitoring and improvement using CPD.

UNIT I	INTRODUCTION TO POWER QUALITY	9

Terms and definitions– Overloading, under voltage, over voltage - Concepts of transients - Short duration variations such as interruption - Long duration variation such as sustained interruption - Sags and swells - Voltage sag - Voltage swell - Voltage imbalance – Voltage fluctuations - Power

frequency variations - International standards of power quality. Computer Business Equipment Manufacturers Associations (CBEMA) curve.		
UNIT II	**VOLTAGE SAG AND SWELL**	**9**
Estimating voltage sag performance - Thevenin's equivalent source - Analysis and calculation of various faulted condition - Estimation of the sag severity - Estimation of Motor Starting sags - Mitigation of voltage sag, Static transfer switches and fast transfer switches. - Capacitor switching – Lightning - Ferro resonance - Mitigation of voltage swell.		
UNIT III	**HARMONICS**	**9**
Harmonic sources from commercial and industrial loads - Locating harmonic sources – Power system response characteristics - Harmonics Vs transients. Effect of harmonics – Harmonic distortion - Voltage and current distortions - Harmonic indices: THD, TDD and Related Problems - Inter harmonics – Resonance Harmonic distortion evaluation, IEEE and IEC standards.		
UNIT IV	**PASSIVE POWER COMPENSATORS**	**9**
Principle of Operation of Passive Shunt and Series Compensators, Analysis and Design of Passive Shunt Compensators Simulation and Performance of Passive Power Filters- Limitations of Passive Filters Parallel Resonance of Passive Filters with the Supply System and its Mitigation. Fundamentals of load compensation – Voltage regulation & power factor correction.		
UNIT V	**POWER QUALITY MONITORING & IMPROVEMENT**	**9**
Monitoring considerations – Monitoring and diagnostic techniques for various power quality problems– Power line disturbance analyzer – Quality measurement equipment – Harmonic spectrum analyzer – Flicker meters – Disturbance analyzer – Load compensation using DSTATCOM, Voltage regulation using DSTATCOM, protecting sensitive loads using DVR, UPQC.		
		TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Explain the concepts of transients, sags and swells.
CO2: Illustrate the voltage sag performance and its mitigation techniques.
CO3: Summarize the effects of harmonics and distortions.
CO4: Demonstrate the passive shunt compensators design.
CO5: Outline the concepts of monitoring and diagnostic techniques of power quality problems.

TEXT BOOKS:

1. Roger. C. Dugan, Mark. F. Mc Granagham, Surya Santoso, H.Wayne Beaty, "Electrical Power Systems Quality", 1st Edition, McGraw Hill,2003
2. J. Arrillaga, N.R. Watson, S. Chen, "Power System Quality Assessment", 1st Edition, Wiley, 2000.
3. Bhim Singh, Ambrish Chandra, Kamal Al-Haddad, "Power Quality Problems & Mitigation Techniques" 1st Edition, Wiley, 2015.
4. Heydt, G.T., "Electric Power Quality", Stars in a Circle Publications, Indiana, 2nd Edition 1996.

REFERENCES:

1. Arindam Ghosh and Gerald Ledwich "Power Quality Enhancement Using Custom Power Devices", 1st Edition, Kluwer Academic Publishers, 2002.
2. Barry W.Kennedy "Power Quality Primer", 1st Edition, McGraw-Hill, New York, 2000.
3. R.C. Duggan, Mark.F.McGranaghan, Surya Santoas and H.WayneBeaty, "Electrical Power System Quality", 1st Edition, McGraw-Hill, 2004.

4. Derek A. Paice , " Power Electronics Converter Harmonics : Multi-pulse methods for clean power", 1st Edition, Wiley Publications, 1999.

21PEE04	RESTRUCTURED POWER SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To explain the process of restructuring of power industry.
- To compare the fundamental concepts of different market models.
- To infer the concepts of economics of restructured power market.
- To outline the concepts of transmission pricing.
- To illustrate about the ancillary services and various power sectors in India.

UNIT I	INTRODUCTION TO RESTRUCTURING OF POWER INDUSTRY	9

Introduction - Reasons for restructuring - deregulation of power industry - Understanding the restructuring process - Entities involved - The levels of competition - The market place mechanisms - Sector-wise major changes required - Introduction to issues involved in deregulation - Reasons and objectives of deregulation of various power systems across the world.

UNIT II	THE PHILOSOPHY OF MARKET MODELS	9

Introduction - Market models based on contractual arrangements - Comparison of various market models - Electricity vis-à-vis other commodities - Market architecture - Discriminatory or non-discriminatory pricing - . Simple bids or complex bids - . Day-ahead and real-time market Models for trading arrangements - Integrated or centralized model - ISO or TSO model.

UNIT III	FUNDAMENTALS OF ECONOMICS	9

Introduction - Consumer behavior - Supplier behavior - Market equilibrium - Short-run and Long-run costs- Various costs of production - Relationship between short-run and long-run average costs - Perfectly competitive market -The firm's supply decision under perfect competition.

UNIT IV	PRICING OF TRANSMISSION NETWORK USAGE	9

Introduction to transmission pricing - power wheeling - Issues involved - Principles of transmission pricing - Classification of transmission pricing methods - Rolled-in transmission pricing methods- Marginal transmission pricing paradigm - Composite pricing paradigm - Merits and de-merits of different paradigms - Debated issues in transmission Pricing.

UNIT V	ANCILLARY SERVICES AND REFORMS IN INDIAN POWER SECTOR	9

Introduction to ancillary services - Types of ancillary services - Classification of ancillary services - Load-generation balancing related services- Voltage control and reactive power support services- Black start capability service - Markets for ancillary services - Framework of Indian power sector - Reform initiatives during 1990-1995 - The availability based tariff (ABT) - The Electricity Act 2003 - Open Access issues - Power exchange- Reforms in near future.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Illustrate the restructuring of power industry.
CO2: Outline the basics of various market models.
CO3: Illustrate about fundamentals of economics in Restructured Power System.
CO4: Explain the significance of pricing methods of transmission network.
CO5: Compare the various power sectors in India and Ancillary System.

TEXT BOOKS:

1. Daniel Kirschen and Goran Strbac, "Fundamentals of Power System economics", 1st Edition, John Wiley & Sons Ltd, 2004.
2. Mohammad Shahidehpour, Muwaffaq Alomoush, Marcel Dekker, "Restructured electrical power systems: operation, trading and volatility" 1st Edition, CRC Press, 2001.
3. Kankar Bhattacharya, Jaap E. Daadler, Math H.J. Boolen, "Operation of restructured power systems", 1st Edition, Kluwer Academic Pub., 2001.
4. Daniel Kirschen and GoranStrbac, 'Fundamentals of Power System economics', 1st Edition, JohnWiley & Sons Ltd, 2004.

REFERENCES:

1. Sally Hunt, 'Making competition work in electricity', 1st Edition, John Wiley & Sons, Inc., 2002.
2. Steven Stoft, "Power system economics: designing markets for electricity", 1st Edition, JohnWiley & Sons, 2002.
3. Loi Lei Lai, 'Power system restructuring and deregulation', 1st Edition, John Wiley & Sons Ltd., 2001.
4. Marijallic, Francisco Galiana and Lestor Fink, "Power System Restructuring Engineering and Economics', 1st Edition, Kulwer Academic Publisher, USA, 1998.

21PEE05	POWER SYSTEMS TRANSIENTS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To outline the importance of transients in power system.
- To summarize different over voltages due to switching transients
- To explain the behavior of lightning transients
- To illustrate the concept of travelling waves
- To interpret the effect of transients in the performance of integrated power system.

UNIT I	INTRODUCTION AND SURVEY	9

Review and importance of the study of transients - causes for transients. RL circuit transient with sine wave excitation - double frequency transients - basic transforms of the RLC circuit transients. Different types of power system transients - effect of transients on power systems – role of the study of transients in system planning.

UNIT II	SWITCHING TRANSIENTS	9

Over voltages due to switching transients - resistance switching and the equivalent circuit for interrupting the resistor current - load switching and equivalent circuit - waveforms for transient voltage across the load and the switch - normal and abnormal switching transients. Current suppression - current chopping - effective equivalent circuit. Capacitance switching - effect of source regulation - ferro resonance.

UNIT III	LIGHTNING TRANSIENTS	9

Review of the theories in the formation of clouds and charge formation - rate of charging of thunder clouds – mechanism of lightning discharges and characteristics of lightning strokes – model for lightning stroke - factors contributing to good line design - protection using ground wires - tower footing resistance - Interaction between lightning and power system.

UNIT IV	TRAVELING WAVES ON TRANSMISSION LINE COMPUTATION OF TRANSIENTS	9
Computation of transients - transient response of systems with series and shunt lumped parameters and distributed lines. Traveling wave concept - step response - Bewely's lattice diagram - standing waves and natural frequencies - reflection and refraction of travelling waves.		
UNIT V	**TRANSIENTS IN INTEGRATED POWER SYSTEM**	**9**
Short line and kilometric fault - distribution of voltages in a power system - Line dropping and load rejection - voltage transients on closing and reclosing lines - over voltage induced by faults - switching surges on integrated system Qualitative application of EMTP for transient computation.		
	TOTAL: 45 PERIODS	

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Summarize the causes of transients in power system.
CO2: Outline the over voltages due to switching transients.
CO3: Explain the effect of lightning strokes in power system.
CO4: Interpret the concept of travelling waves in distributed lines.
CO5: Illustrate the transient performance of integrated power system with EMTP software.

TEXT BOOKS:

1. Allan Greenwood, 'Electrical Transients in Power Systems', 2nd Edition, Wiley Inter Science, New York, 1991.
2. Pritindra Chowdhari, "Electromagnetic transients in Power System", 2nd Edition, John Wiley and Sons Inc., 2009.
3. C.S. Indulkar, D.P.Kothari, K. Ramalingam, 'Power System Transients – A statistical approach', 2nd Edition, PHI Learning Private Limited, 2010.
4. Akihiro Ametani "Power System Transient theory and applications", 2nd Edition. CRC press, 2013.

REFERENCES:

1. M.S.Naidu and V.Kamaraju, 'High Voltage Engineering', 5th Edition, Tata McGraw Hill, 2013.
2. R.D. Begamudre, 'Extra High Voltage AC Transmission Engineering', 3rd Edition, Wiley Eastern Limited, 1986.
3. Y.Hase, Handbook of Power System Engineering," 2nd Edition, Wiley India, 2012.
4. J.L.Kirtley, "Electric Power Principles, Sources, Conversion, Distribution and use," 2nd Edition, Wiley India, 2012.

21PEE06	DISTRIBUTED GENERATION AND MICROGRID	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To summarize the conventional and NCE resources.
- To explain the concept of distributed generation.
- To illustrate the knowledge in impact of grid integration.
- To outline the concept of microgrid and its configuration.
- To demonstrate the various control operations of microgrid.

UNIT I	INTRODUCTION	9
Conventional power generation: advantages and disadvantages, Energy crises, Non- conventional		

energy (NCE) resources: review of Solar PV, Wind Energy systems, Fuel Cells, micro-turbines, biomass, and tidal sources.

UNIT II	DISTRIBUTED GENERATIONS (DG)	9

Concept of distributed generations, topologies, selection of sources, regulatory standards/framework, Standards for interconnecting Distributed resources to electric power systems: IEEE 1547. DG installation classes, security issues in DG implementations. Energy storage elements: Batteries, ultra-capacitors, flywheels. Captive power plants.

UNIT III	IMPACT OF GRID INTEGRATION	9

Requirements for grid interconnection, limits on operational parameters: voltage, frequency, THD, response to grid abnormal operating conditions, islanding issues. Impact of grid integration with NCE sources on existing power system: reliability, stability and power quality issues.

UNIT IV	BASICS OF MICROGRID	9

Concept and definition of microgrid, microgrid drivers and benefits, review of sources of microgrids, typical structure and configuration of a microgrid, AC and DC microgrids, Power Electronics interfaces in DC and AC microgrids.

UNIT V	CONTROL AND OPERATION OF MICROGRID	9

Modes of operation and control of microgrid: grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes: passive, active and communication based techniques, microgrid communication infrastructure, Power quality issues in microgrids, regulatory standards, Microgrid economics, Introduction to smart microgrids.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Explain the various schemes of conventional and Non-conventional power generation.
CO2: Summarize different topologies and energy sources of distributed generation.
CO3: Interpret the requirements for grid interconnection and its impact with NCE sources.
CO4: Illustrate the basic operation of Micro grid.
CO5: Outline the various control operations of micro grid.

TEXT BOKS:

1. Math H. J. Bollen, FainanHussain," Integration of distributed generation power system" 2nd Edition ,Wiley IEEE press, 2011.
2. Qing - Chang Zhong, Tomas Hornlk, "Control of Power Inverters in Renewable Energy and Smart Grid Integration" 1st Edition Wiley IEEE Press, 2012.
3. D. Hall and R. P. Grover, "Biomass Regenerable Energy", 2nd Edition John Wiley, New York, 1987.
4. John Twidell and Tony Weir, "Renewable Energy Resources" , 2nd Edition ,Taylor and Francis Publications, 2006.

REFERENCE BOOKS:

1. Amirnaser Yezdani, and Reza Iravani, "Voltage Source Converters in Power Systems: Modeling, Control and Applications", 2nd Edition IEEE John Wiley Publications, 2010.
2. Dorin Neacsu, "Power Switching Converters: Medium and High Power", 1st Edition, Taylor & Francis, 2006.
3. Chetan Singh Solanki, "Solar Photo Voltaics, Fundamentals, Technologies and Applications", 1st Edition, PHI learning Pvt. Ltd., New Delhi, 2009.

4. J.F. Manwell, J.G. McGowan "Wind Energy Explained, Theory design and applications", 1st Edition, Wiley publication, 2010.

21PEE07	ENERGY MANAGEMENT AND AUDITING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To explain the various steps involved in an energy auditing process.
- To outline the concepts behind electricity billing and load management.
- To interpret the need for energy management on various electrical equipment.
- To illustrate the concept of lighting systems.
- To summarize the performance assessment made on various utilities and its need.

UNIT I	INTRODUCTION	9

Definition, Energy audit- Need for energy management - energy basics- energy accounting -energy monitoring, targeting and reporting- energy audit process- Types of energy audit, matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution, Energy audit instruments

UNIT II	ECONOMIC ANALYSIS AND LOAD MANAGEMENT	9

Definition of load management- Demand control techniques- Utility monitoring and control system - Economic justification for load management systems -Economic analysis - Economic models-models-applications and limitations-Time value of money-Utility rate structures- Calculating the cost of electricity-Loss evaluation.

UNIT III	ELECTRICAL EQUIPMENTS AND METERING SYSTEM	9

Electric motors-Transformers and reactors-Capacitors and synchronous machines. Relationships between parameters-Units of measure-Typical cost factors- Utility meters - Timing of meter disc for kilowatt measurement - Demand meters - Paralleling of current transformers - Instrument transformer burdens-Multitasking solid-state meters - Metering location vs. requirements- Metering techniques and practical examples.

UNIT IV	LIGHTING SYSTEMS	9

Concept of lighting systems - Task and working space -Light sources - Ballasts - Luminaries - Lighting controls-Optimizing lighting energy - Power factor and effect of harmonics on power quality - Cost analysis techniques-Lighting and energy standards.

UNIT V	ENERGY PERFORMANCE SYSTEMS	9

Performance terms- definition- Purpose of performance test- Performance on Thermal power station- Steel industry- Cement industry- Paper and pulp industry- Textile industry- Fertilizer industry-Building & commercial establishments

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Demonstrate the need for energy management and auditing process
CO2: Explain the load management and economic analysis performed in a system.
CO3: Outline the energy management concepts for electrical equipment and metering system.
CO4: Classify various lighting systems and energy standards.
CO5: Interpret the performance assessment made on various utility systems.

TEXT BOOKS:

1. Barney L. Capehart, Wayne C. Turner, and William J. Kennedy, "Guide to Energy Management", 7th Edition, The Fairmont Press, Inc., 2011.
2. Amit K. Tyagi, "Handbook on Energy Audits and Management", TERI, 2003.
3. Ian M . Shapiro , "Energy audits and improvements for commercial buildings: a guide for energy managers and energy auditors", 1st Edition, John Wiley & Sons, 2016.
4. Moncef Krarti, "Energy Audit of Building Systems: An Engineering Approach", 2nd Edition, CRC Press, 2010.

REFERENCES

1. Frank Kreith, D. Yogi Goswami, "Energy management and conservation handbook", 1st Edition, CRC Press, 2008.
2. Patrik Thollander, Jenny Palm "Improving Energy Efficiency in Industrial Energy Systems: An Interdisciplinary Perspective on Barriers, Energy Audits, Energy Management, Policies, and Programs", 1stEdition, Springer-Verlag London, 2013.
3. General Aspects of Energy Management and Energy Audit, 4th Edition, Bureau of Energy Efficiency India, 2015.
4. Anil Kumar, Om Prakash, Prashant Singh Chauhan, Samsher Gautam, "Energy Management-Conservation and Audits", 1st Edition, CRC Press, 2020.

21PEE08	POWER SYSTEM DYNAMICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To illustrate dynamic modeling of a synchronous machine.
- To explain the modeling concepts of excitation systems.
- To outline transient, steady state and dynamic stability.
- To interpret numerical integration methods for power system stability analysis
- To summarize the effects of stability in single machine infinite bus system.

UNIT I	MODELLING OF SYNCHRONOUS MACHINES	9

Simplest model of the synchronous machine – circuit equations – equation in physical quantities - Inductance of Synchronous Machine - Park's transformation - dq0 components – assumptions of balanced currents and voltages in the armature – phasor diagram – equivalent circuit – reactance – final machine dynamic equations – inclusion of damper winding.

UNIT II	MODELLING OF EXCITATION SYSTEMS	9

Excitation system requirements - elements of an excitation system – types of excitation system – dynamic performance measure – control and protective functions – modelling of excitation system.

UNIT III	POWER SYSTEM STABILITY	9

Power system stability considerations – definitions - classification of stability - rotor angle and voltage stability - stability of interconnected systems – bad effects of instability – Importance of stability to system operation and design.

UNIT IV	TRANSIENT STABILITY	9

Inertia constant and equivalent inertia constant – power angle curve – swing equation – point by point solution- transient stability - swing equation - equal area criterion - solution of swing equation - Euler method - Runge-Kutta method - critical clearing time and angle.

UNIT V	SMALL SIGNAL STABILITY	9

State space representation - small signal stability of single machine infinite bus system (SMIB) – synchronous machine classical model representation - effect of field circuit dynamics- effect of excitation system – Power system stabilizer for small signal stability improvement.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to

CO1: Explain the dynamic modelling of synchronous machine.
CO2: Illustrate the modeling of excitation system for stability analysis.
CO3: Classify the power system stability with its effects on interconnected systems.
CO4: Experiment with Modified Euler's and Runge – Kutta method for stability analysis
CO5: Show the effects of small signal stability analysis in power system.

TEXT BOOKS:

1. P. W. Sauer and M. A. Pai, "Power System Dynamics and Stability", 1st Edition, Prentice Hall, 1998.
2. P. Kundur, "Power System Stability and Control", 1st Edition, McGraw-Hill, 1993.
3. P.M Anderson and A.A Fouad, "Power System Control and Stability", 1st Edition, Iowa State University Press, Ames, Iowa, 1978.
4. R.Ramanujam,"Power System Dynamics Analysis and Simulation", 1st Edition, PHI Learning Private Limited, New Delhi, 2009.

REFERENCES:

1. E.W.Kimbark, "Power System Stability" vol.1, 1st Edition, John Wiley,1995.
2. James A.Momoh, Mohamed. E. EI-Hawary. "Electric Systems, Dynamics and Stability with Artificial Intelligence applications", 1st Edition, Marcel Dekker, USA, 2000.
3. MirceaEremia and Mohammad Shahidehpour, "Handbook of Electrical Power System Dynamics: Modeling, Stability and Control", 1st Edition, IEEE Press Series on Power Engineering, 2013.
4. L.P.Singh, "Advanced Power system Analysis and Dynamics", 6th Edition, New Age International Publishers, 2012.

VERTICAL II - POWER CONVERTERS AND DRIVES

21PEE09	MODERN POWER CONVERTERS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To explain the switched mode regulator for various industrial applications.
- To interpret the characteristics of Switched mode AC-DC converters
- To illustrate the characteristics and performance of multilevel inverters.
- To outline the performance of AC-AC Converters with and without DC Link
- To compare hard switched and soft switched converters and explain the soft switching techniques.

UNIT I	SWITCHED MODE POWER SUPPLY (SMPS)	9

DC Power supply and Classification; Switched mode dc power supply - with and without isolation, single and multiple outputs; Closed loop control and regulation; Design examples on converter and closed loop performance.

UNIT II	AC-DC CONVERTERS	9

Switched mode AC-DC converters, synchronous rectification - single and three phase topologies - switching techniques-with and without input-output isolation. performance indices design examples -Difference Between diode rectifiers and phase controlled rectifiers-Applications.

UNIT III	DC-AC CONVERTERS	9

Multi-level Inversion - concept, classification of multilevel inverters, Principle of operation, features and analysis of Diode clamped, Flying capacitor and cascaded multilevel inverters; Modulation schemes. Application of Multilevel Inverters**.**

UNIT IV	AC-AC CONVERTERS WITH AND WITHOUT DC LINK	9

Matrix converters. Basic topology of matrix converter; Commutation – current path; Modulation techniques - scalar modulation, indirect modulation; Matrix converter as only AC-DC converter; AC-AC converter with DC link - topologies and operation - with and without resonance link - converter with dc link converter-Applications.

UNIT V	SOFT-SWITCHING POWER CONVERTERS	9

Soft switching techniques. ZVS, ZCS, quasi resonance operation; Performance comparison hard switched and soft switched converters.AC-DC converter, DC-DC converter, DC-AC converter.; Resonant DC power supplies.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Interpret switched mode DC power supply for various industrial applications.
CO2: Explain the characteristics of Switched mode AC-DC converters with and without isolation.
CO3: Summarize the different types of multilevel inverters.
CO4: Outline the bidirectional switch with and without DC link.
CO5: Illustrate the soft switching power converters with resonant DC link.

TEXT BOOKS:

1. Mohammed H. Rashid, "Power Electronics", 4th Edition ,Pearson Education ,2018.
2. Ned Mohan, Tore M. Undeland and William P. Robbins, "Power Electronics", 2nd Edition,Pearson Education,2014.

3. Daniel W. Hart, "Power Electronics ", 1st Edition , McGraw Hill Publications, 2011.
4. V. R. Moorthi , "Power Electronics Devices, Circuits and Industrial applications", 1st Edition ,Oxford University Press, 2005.
5. Dr. P. S. Bimbhra ," Power Electronics" , 6th Edition , Khanna Publishers, 2019.

REFERENCES

1. Philip T. Krein , "Elements of Power Electronics", 2nd Edition, Oxford University Press, 2015.
2. Robert W. Erickson, Dragan and Maksimobic, "Fundamentals of Power Electronics", 2nd Edition, Springer, 2015.
3. Joseph Vithayathil , "Power Electronics, Principles and Applications", 6th Reprint, McGraw Hill Series, 2013.
4. Ashfaq Ahmed, "Power Electronics for Technology",1st Edition, Pearson Education, , Indian reprint, 2003.

21PEE10	SWITCHED MODE POWER CONVERTERS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To explain the modern power electronic converters and its applications in electric power utility.
- To show the operation of switched mode power converters
- To outline the operation of resonant converters and UPS
- To illustrate the operation of the DC-AC converters.
- To interpret the operation and performance of power conditioners and filters.

UNIT I	DC-DC CONVERTERS	9

Principles of step down and step up converters – Analysis and state space modeling of Buck, Boost, Buck- Boost and Cuk converters.

UNIT II	POWER CONVERTERS	9

Analysis and state space modeling of fly back,- Forward, - Push pull, - Luo, - Half bridge and full bridge converters- control circuits and PWM techniques.

UNIT III	RESONANT CONVERTERS	9

Introduction- classification- basic concepts- Resonant switch- Load Resonant converters ZVS ,Clamped voltage topologies- DC link inverters with Zero Voltage Switching- Series and parallel Resonant inverters- Voltage control.

UNIT IV	DC-AC CONVERTERS	9

Single phase and three phase inverters, control using various (sine PWM, SVPWM and PSPWM) techniques, various harmonic elimination techniques- Multilevel inverters Concepts – Types: Diode clamped- Flying capacitor- Cascaded types- Applications.

UNIT V	POWER CONDITIONERS, UPS & FILTERS	9

Introduction- Power line disturbances- Power conditioners –UPS: offline UPS, Online UPS, Applications – Filters: Voltage filters, Series-parallel resonant filters, filter without series capacitors, filter for PWM VSI, current filter, DC filters – Design of inductor and transformer for PE applications – Selection of capacitors

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Outline the state space model for DC – DC converters
CO2: Illustrate the operation of switched mode power converters.
CO3: Explain the importance of Resonant Converters.
CO4: Summarize the PWM techniques for DC-AC converters
CO5: Relate the operation of filters and UPS

TEXT BOOKS:

1. Simon Ang, Alejandro Oliva," Power-Switching Converters", 3rd Edition, CRC Press, 2010.
2. KjeldThorborg, "Power Electronics – In theory and Practice", 1st Edition, Overseas Press, 2005.
3. M.H. Rashid – "Power Electronics handbook", 4th Edition, Elsevier Publication, 2017.
4. GopalK.Dubey, "Power semiconductor controlled Drives", 1st Edition, Prentice Hall Inc., NewJersey,1989.

REFERENCES

1. Philip T Krein, "Elements of Power Electronics", 2ndEdition, Oxford University Press, 2017.
2. Ned Mohan, Tore.M.Undeland, William.P.Robbins, "Power Electronics converters, Applications and design",3rd Edition, John Wiley and Sons, 2006
3. M.H. Rashid "Power Electronics circuits, devices and applications"- 3rdEdition, Prentice Hall of India New Delhi, 2007.
4. Erickson, Robert W, "Fundamentals of Power Electronics",2nd Edition, Springer, 2010.

21PEE11	POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To explain about Renewable Energy System and its environmental impacts.
- To illustrate various electrical machines for Wind Energy Conversion System.
- To summarize different power converters namely AC to DC, DC to DC and AC to AC converters for renewable energy systems.
- To demonstrate the concept of wind and PV systems.
- To outline the maximum power point tracking algorithms and hybrid energy system.

UNIT I	INTRODUCTION	9

Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment (cost-GHG Emission) – Global warming and climate change impacts - Qualitative study of different renewable energy resources: Solar, Wind, Ocean, Biomass, Fuel cell, Hydrogen energy systems and Hybrid renewable energy systems.

UNIT II	ELECTRICAL MACHINES FOR RENEWABLE ENERGY CONVERSION	9

Review of 3 Phase Induction Motor – Construction & Principle, Review of reference theory fundamentals – Principle of operation and analysis: IG, PMSG, SCIG and DFIG.

UNIT III	POWER CONVERTERS	9

Solar: Block diagram of solar photo voltaic system -Principle of operation: line commutated converters (inversion-mode) - Boost and buck-boost converters- selection of inverter, battery sizing, array sizing Wind: Three phase AC voltage controllers- AC-DC-AC converters:

uncontrolled rectifiers, PWM Inverters, Grid Interactive Inverters-matrix converters.		
UNIT IV	**ANALYSIS OF WIND AND PV SYSTEMS**	**9**
Solar radiation and measurement – Solar cells and their characteristics – PV arrays – Introduction to flexible solar cells –Basic Principle of wind Energy conversion – Components and classification of Wind Energy Conversion System (WECS) – Smart grid.		
UNIT V	**HYBRID RENEWABLE ENERGY SYSTEMS**	**9**
Need for Hybrid Systems- Range and type of Hybrid systems- Case studies of Wind-PV Maximum Power Point Tracking (MPPT). - Converters for hybrid renewable energy system - Recent Developments in Multilevel converters – Smart meters.		
	TOTAL: 45 PERIODS	

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Demonstrate the working principle of various renewable energy resources with its environmental impacts.

CO2: Illustrate the principle, operation & characteristics of various machines for renewable energy systems.

CO3: Outline the performance characteristics of various power converters.

CO4: Explain the principle of energy conversion and grid integration schemes for wind & solar systems.

CO5: Summarize various types of hybrid renewable energy systems for MPPT.

TEXT BOOKS:

1. S. N. Bhadra, D.Kastha, S.Banerjee,"Wind Electrical Systems", 1st Edition,Oxford University Press,2005.
2. Ion Boldea, "Variable speed generators", 1st Edition, Taylor& Francis group, 2006.
3. Chetan Singh Solanki ,"Solar Photovoltaics: Fundamentals, Technologies And Applications", 3rd Edition, 2015.
4. Haitham Abu-Rub; Mariusz Malinowski; Kamal Al-Haddad, " Power Electronics for Renewable Energy Systems, Transportation and Industrial Applications", 3rd Edition, Wiley-IEEE Press,2014.

REFERENCES

1. Rashid .M. H "power electronics Hand book", 2rd Edition, Academic press, 2001.
2. B.H.Khan "Non-conventional Energy sources ", 3rd Edition, Tata McGraw-hill Publishing Company, New Delhi, 2009.
3. Rai. G.D, "Non conventional energy sources", 3rd Edition, Khanna publishes, 1993.
4. Gray, L. Johnson, "Wind energy system", 2rd Edition, Prentice Hall linc, 1995.

21PEE12	SPECIAL ELECTRICAL MACHINES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To interpret the construction, principle of operation, control and performance of stepper motors.
- To explain the construction, principle of operation and performance of synchronous reluctance motors.
- To infer the construction, principle of operation, control and performance of switched reluctance motors.

- To outline the construction, principle of operation, control and performance of permanent magnet brushless DC motors.
- To illustrate the construction, principle of operation and performance of permanent magnet synchronous motors

UNIT I	**STEPPER MOTORS**	**9**

Constructional features – Principle of operation – Variable reluctance motor – Hybrid motor – Single and multi stack configurations – Torque equations – Modes of excitation – Characteristics – Drive circuits – Microprocessor control of stepper motors – Closed loop control-Concept of lead angle– Applications.

UNIT II	**SYNCHRONOUS RELUCTANCE MOTORS**	**9**

Constructional features – Types – Axial and Radial flux motors – Principle of operation – Variable Reluctance Motors – Voltage and Torque Equations - Phasor diagram - performance characteristics – Applications.

UNIT III	**SWITCHED RELUCTANCE MOTORS**	**9**

Constructional features – Rotary and Linear SRM - Principle of operation – Torque equation – Steady state performance prediction- Analytical method -Power Converters and their controllers – Methods of Rotor position sensing – Sensor less operation – Characteristics and Closed loop control – Applications.

UNIT IV	**PERMANENT MAGNET BRUSHLESS DC MOTORS**	**9**

Permanent Magnet materials – Minor hysteresis loop and recoil line-Magnetic Characteristics – Permeance coefficient -Principle of operation – Types – Magnetic circuit analysis – EMF and torque equations –Commutation - Power Converter Circuits and their controllers – Motor characteristics and control– Applications.

UNIT V	**PERMANENT MAGNET SYNCHRONOUS MOTORS**	**9**

Principle of operation – Ideal PMSM – EMF and Torque equations – Armature MMF – Synchronous Reactance – Sine wave motor with practical windings - Phasor diagram – Torque/speed characteristics - Power controllers - Converter Volt-ampere requirements– Applications.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Explain the performance of stepper motors.
CO2: Illustrate characteristics and performance of synchronous reluctance motors.
CO3: Demonstrate the controllers for switched reluctance motors.
CO4: Summarize the performance and applications of permanent magnet brushless DC motors.
CO5: Outline the performance and characteristics of permanent magnet synchronous motors.

TEXT BOOKS:

1. K.Venkataratnam, "Special Electrical Machines", 1st Edition, Universities Press (India) Private Limited, 2008.
2. T.J.E. Miller, "Brushless Permanent Magnet and Reluctance Motor Drives", 1st Edition, Clarendon Press, Oxford, 1989.
3. T. Kenjo, "Stepping Motors and Their Microprocessor Controls", 1st Edition, Clarendon Press London, 1984.
4. E.G. Janardanan, "Special electrical machines", 1st Edition, PHI learning Private

Limited, Delhi, 2014.

REFERENCES

1. R.Krishnan, "Switched Reluctance Motor Drives – Modeling, Simulation, Analysis, Design and Application",1st Edition, CRC Press, New York, 2001.
2. P.P. Aearnley, "Stepping Motors – A Guide to Motor Theory and Practice", 1st Edition, Peter Perengrinus London, 2002.
3. T. Kenjo and S. Nagamori, "Permanent Magnet and Brushless DC Motors", 1st Edition, Clarendon Press, London, 1989.
4. R.Srinivasan, "Special Electrical Machines", 1st Edition, Lakshmi Publications, 2013.

21PEE13	SOLID STATE DRIVES AND CONTROL	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To explain the steady state characteristics of electrical drive
- To relate the operation of the converter / chopper fed DC drive.
- To illustrate the characteristics and performance of induction motor drives.
- To summarize the application of synchronous motor drives.
- To outline the controllers for DC drives.

UNIT I	DRIVE CHARACTERISTICS	9

Electrical drive-Equations governing motor load dynamics – steady state stability – multi quadrant Dynamics: acceleration, deceleration, starting & stopping – four quadrant load torque characteristics- Selection of motor.

UNIT II	CONVERTER / CHOPPER FED DC MOTOR DRIVE	9

Steady state analysis of the single and three phase converter fed separately excited DC motor drive – continuous and discontinuous conduction – Time ratio and current limit control – four quadrant operation of converter / chopper fed drive-Applications.

UNIT III	INDUCTION MOTOR DRIVES	9

Stator voltage control – Rotor resistance control, qualitative treatment of slip power recovery drives-V/f control –voltage / current fed inverter – closed loop control-Vector control application.

UNIT IV	SYNCHRONOUS MOTOR DRIVES	9

V/f control and self-control of synchronous motor: Margin angle control and power factor control –Three phase voltage / current source fed synchronous motor –Applications**.**

UNIT V	SPECIAL MACHINES DRIVES	9

Transfer function for DC motor / load and converter – closed loop control with current and speed feedback – armature voltage control and field weakening mode .design of controllers-current controller and speed controller.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Show the steady state operation of various drives with its torque characteristics
CO2: Illustrate the operation of the converter / chopper fed DC drive.
CO3: Explain the operation of both classical and modern induction motor drives

CO4: Demonstrate the design of synchronous motor drives
CO5: Outline the concept of current and speed controller for drives

TEXT BOOKS:

1. Gopal K.Dubey, "Fundamentals of Electrical Drives", 2nd Edition, Narosa Publishing House, 2010.
2. Bimal K.Bose. "Modern Power Electronics and AC Drives", 1st Edition, Pearson Education, 2002.
3. Gopal K .Dubey, "Power semiconductor controlled Drives", 1st Edition, Prentice Hall Inc., New Jersey, 1989.
4. R.Krishnan, "Electric Motor & Drives: Modeling, Analysis and Control", 1st Edition, Prentice hall of India, 2001.

REFERENCES

1. S.K.Pillai, "A First course on Electrical Drives", 1st Edition, Wiley Eastern Limited,1993.
2. Murphy J.M.D and Turnbull, "Thyristor Control of AC Motor", 1st Edition, Pergamon Press, Oxford, 1988.
3. J.Gnanavadivel,"Solid State Drives", 1st Edition, Anuradha Publications, Chennai. 2017.
4. Philip T.Krein, "Elements of Power Electronics" 1st Edition, Oxford University Press, 2004.

21PEE14	DIGITAL CONTROL OF ELECTRICAL DRIVES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To outline the concepts of power electronic converters.
- To explain modeling of DC motor, drives and control techniques
- To demonstrate the modelling and analysis of Induction motor drive.
- To interpret V/f and vector control for Induction motor drive.
- To illustrate the control of embedded drives.

UNIT I	POWER ELECTRONIC CONVERTERS FOR DRIVES	9

Power electronic switches-state space representation of switching converters - Fixed frequency PWM-variable frequency PWM- space vector PWM- Hysteresis current control-dynamic analysis of switching converters-PWM modulator model.

UNIT II	CONTROL OF DC DRIVES	9

Modelling of DC machines-block diagram/transfer function-phase control – 1-phase/ 3-phase converter fed DC drives- Chopper fed DC drives-four quadrant chopper circuit - closed loop control - speed control - current control - cascade control – constant torque/power operation-comparison of chopper/converter fed drives techniques-merits/demits.

UNIT III	ANALYSIS AND MODELLING OF INDUCTION MOTOR DRIVE	9

Basics of induction motor drive-classification – equivalent circuit- torque Vs slip characteristics-steady state performance- Dynamic modeling of induction motor, 3-phase to two phase transformation-stator, rotor, and synchronously rotating reference frame model.

UNIT IV	CONTROL OF INDUCTION MOTOR DRIVE	9

VSI fed induction motor drives- waveforms for 1-phase, 3-phase Non-PWM and PWM VSI fed induction motor drives -principles of V/F control- principle of vector control-direct vector control- space vector modulation- indirect vector control.

UNIT V	EMBEDDED CONTROL OF DRIVES	9
Generation of firing pulses- generation of PWM pulses using embedded processors - IC control of DC drives- fixed frequency/variable frequency/current control- V/F control using PIC microcontroller- vector control using embedded processors.		
	TOTAL: 45 PERIODS	

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Outline the concept of PWM converters.
CO2: Illustrate the controlling methods of DC drives.
CO3: Interpret the dynamic modeling for Induction motor drive.
CO4: Summarize the controlling methods of Induction motor drive.
CO5: Explain the vector control of drives using embedded processors.

TEXT BOOKS:

5. R. Krishnan, "Electric Motor Drives, Modeling, Analysis and Control", 1st Edition, Prentice Hall of India, 2002.
6. Raj Kamal, "Embedded Systems- Architecture, Programming and Design", 1st Edition, Tata McGraw Hill Publications, 2006.
7. Vedam Subrahmanyam, "Thyristor control of Electric drives", 2nd Edition, Tata McGraw Hill Publications, 1988.
8. D.M. Dhamdhere," Operating Systems, A Concept-Based Approach", 2nd Edition, Tata McGraw Hill Publications, 2008.

REFERENCES

1. Ion Boldea & S.A. Nasar, "Electric Drives", 1st Edition, CRC Press, 2006.
2. Simon Ang, Alejandro Oliva "Power Switching Converters", 1st Edition, CRC Press,2005.
3. B.R. Gupta, V. Singhal, "Fundamentals of Electric Drives and Control", 1st Edition, S.K. Kataria & Sons Publishers, 2013.
4. Duco W. J. Pulle, "Applied Control of Electrical Drives: Real Time Embedded and Sensorless Control using VisSim and PLECS", 1st Edition, Springer, 2015.

21PEE15	WIND ENERGY CONVERSION SYSTEM	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To explain the basic concepts of Wind energy conversion system
- To illustrate the mathematical modeling and control of the Wind turbine.
- To outline the concepts of fixed speed wind energy conversion systems.
- To summarize the concepts of variable speed wind energy conversion systems.
- To interpret the grid integration issues with wind energy conversion systems.

UNIT I	INTRODUCTION	9
Components of WECS-WECS schemes-Power obtained from wind-simple momentum theory-Power coefficient-Sabinin's theory-Aerodynamics of Wind turbine.		
UNIT II	**WIND TURBINES**	**9**
HAWT-VAWT (Horizontal and Vertical Axis Wind Turbine) -Power developed-Thrust-Efficiency-Rotor selection-Rotor design considerations- Tip speed ratio-No. of Blades-Blade profile-Power Regulation-yaw control-Pitch angle control and stall control-Schemes for		

maximum power extraction.		
UNIT III	**FIXED SPEED SYSTEMS**	**9**
Generating Systems- Constant speed constant frequency systems -Choice of Generators-Deciding factors-Synchronous Generator-Squirrel Cage Induction Generator- Model Wind speed - Model wind turbine rotor - Drive Train model- Generator model for Steady state and Transient stability analysis.		
UNIT IV	**VARIABLE SPEED SYSTEMS**	**9**
Need of variable speed systems-Power-wind speed characteristics-Variable speed constant frequency systems synchronous generator- DFIG (doubly-fed induction generator) - PMSG (Permanent Magnet synchronous Generator) -Variable speed generators modeling - Variable speed variable frequency schemes.		
UNIT V	**GRID CONNECTED SYSTEMS**	**9**
Wind interconnection requirements, low-voltage ride through (LVRT), ramp rate limitations, and supply of ancillary services for frequency and voltage control, current practices and industry trends wind interconnection impact on steady-state and dynamic performance of the power system including modeling issue.		
		TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Summarize the concepts of Wind energy conversion system.
CO2: Interpret the control and modeling of Wind turbine.
CO3: Explain the Fixed speed system types.
CO4: Illustrate the characteristics of variable speed systems.
CO5: Outline the issues of Grid connected wind energy conversion system.

TEXT BOOKS:

1. L.L.Freris "Wind Energy conversion Systems", 1st Edition, Prentice Hall, 1990
2. S.N.Bhadra, D.Kastha, S.Banerjee, "Wind Electrical Systems", 1st Edition, Oxford University Press, 2010.
3. Ion Boldea, "Variable speed generators", 1st Edition, Taylor & Francis group, 2006.
4. S.M.Muyeen, "Wind Energy conversion Systems Technology and Trends", 1st Edition, Springer, 2012.

REFERENCES:

1. E.W.Golding "The generation of Electricity by wind power", 2nd Edition, Redwood burn Ltd., Trowbridge, 1976.
2. N. Jenkins," Wind Energy Technology", 1st Edition, John Wiley & Sons,1997.
3. S.Heir "Grid Integration of WECS", 1st Edition, Wiley 1998.
4. N. Jenkins," Wind Energy Technology", 2nd Edition, John Wiley & Sons, 1997.

21PEE16	**FLEXIBLE AC TRANSMISSION SYSTEM**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To explain the basic concepts of Flexible AC Transmission System (FACTS) controllers in power transmission.
- To illustrate the characteristics and applications of Static Var Compensator (SVC) & Static Compensator (STATCOM) in power transmission

- To summarize the applications of Thyristor Controlled Series Capacitor (TCSC) and Static Synchronous Series Compensator (SSSC)
- To outline the operational characteristics of Unified Power Flow Controller and Interline Power Flow Controllers
- To demonstrate the concepts of special purpose FACTS controllers.

UNIT I	**INTRODUCTION TO FACTS**	**9**

Reactive power control in electrical power transmission lines –Uncompensated transmission line – Fixed series and shunt compensation – Basic types of FACTS controllers – Brief description and definitions of FACTS controllers.

UNIT II	**STATIC SHUNT COMPENSATION**	**9**

Basic operating principle of Static Var Compensators and STATicCOMpensator (STATCOM) – Regulation slope - transfer function and dynamic performance- Comparison between SVC and STATCOM - V-I & V-Q characteristics – Applications: Enhancement of transient stability and power oscillation damping.

UNIT III	**STATIC SERIES COMPENSATORS**	**9**

Concepts of Controlled Series Compensation - Operation of Thyristor Controlled Series Capacitor (TCSC) - Modelling of TCSC for load flow studies - Modelling of Thyristor Switched Series Capacitor (TSSC) for power flow - Applications: Improvement of the system stability limit - Enhancement of power system damping – Sub Synchronous Resonance (SSR) Mitigation.

UNIT IV	**COMBINED SERIES AND SHUNT CONTROLLERS**	**9**

Unified Power Flow Controller (UPFC) – Operating principle – Independent real and reactive power flow control – Dynamic performance – Interline Power Flow Controllers (IPFC) – operating principle – control structure – practical application considerations.

UNIT V	**SPECIAL PURPOSE FACTS CONTROLLERS**	**9**

N G Hingorani (NGH) – SSR damping scheme – Thyristor Controlled Braking Resistor(TCBR) – Design and operating aspects – Application examples – Western Area Power Administration's (WAPA) substation with Advanced Series Capacitor (ASC), Bonneville Power Administration (BPA) system with TCSC.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Outline the need for Flexible AC Transmission System (FACTS) controllers.
CO2: Summarize the applications of Static VAR Compensator (SVC) & Static Compensator (STATCOM).
CO3:Illustrate the applications of Thyristor Controlled Series Capacitor (TCSC) and Thyristor Switched Series Capacitor (TSSC).
CO4: Interpret the operational characteristics of UPFC and Interline Power Flow Controllers.
CO5: Explain the special purpose FACTS controllers in power system

TEXT BOOKS:

1. N.G. Hingorani and L. Gyugyi, "Understanding FACTS: Concepts and Technology Flexible AC Transmission Systems", 2nd Edition, Wiley India publishers, 2011.
2. Mohan Mathur, R., Rajiv. K. Varma, "Thyristor – Based Facts Controllers for Electrical Transmission Systems", 1st Edition, IEEE press and John Wiley & Sons, 2002
3. K.R.Padiyar, "FACTS Controllers in Power Transmission and Distribution", 2nd Edition,

New Age International Publishers, Reprint 2016.
4. V.K. Sood, "HVDC and FACTS controllers- Applications of Static Converters in Power System", 1st Edition, Springer Publishers, 2014.

REFERENCES:

1. K.R.Padiyar, "HVDC Power Transmission Systems", 2nd Edition, New Age International publishers, 2016.
2. A.T.John,"Flexible A.C. Transmission Systems", 1st Edition, Institution of Electrical and Electronic Engineers publishers, 1999.
3. Xiao-Ping Zhang, "Flexible AC transmission systems, Modelling & Control", 2nd Edition, Springer Publications, 2012.
4. Suman Bhowmick, "Flexible AC Transmission Systems (FACTS): Newton Power-Flow Modeling of Voltage-Sourced Converter-Based Controllers", 1st Edition, CRC Press, 2016.

VERTICAL III: EMBEDDED SYSTEM ENGINEERING

21PEE17	MICROCONTROLLER BASED SYSTEM DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To explain the architecture of PIC microcontroller and timers
- To outline the peripheral devices for data communication
- To illustrate the embedded system development process.
- To interpret the functional blocks and assembly language programming of ARM processor.
- To demonstrate the organization of ARM processors and its applications

UNIT I	INTRODUCTION TO PIC MICROCONTROLLER	9

Introduction to PIC Microcontroller–PIC 16C6x and PIC16C7x Architecture– Program Memory considerations – Register File Structure - Instruction Set - Addressing modes –Interrupts- Interrupt Programming–PIC microcontroller Interrupts- Timers.

UNIT II	PERIPHERALS AND INTERFACING	9

I^2C Bus for Peripherals Chip Access– Bus operation-Bus subroutines– Serial EEPROM—Analog to Digital Converter–UART-Baud rate selection–Data handling circuit–Initialization - LCD and keyboard Interfacing -ADC, DAC, and Sensor Interfacing.

UNIT III	EMBEDDED FIRMWARE DEVELOPMENT ENVIRONMENT	9

Embedded Product Development Life Cycle- different phases of EDLC, Modelling of EDLC; issues in Hardware-software Co-design, Data Flow Graph, state machine model, Sequential Program Model, concurrent Model, object oriented Model.

UNIT IV	INTRODUCTION TO ARM PROCESSOR	9

ARM Architecture –ARM programmer's model –ARM Development tools- Memory Hierarchy –ARM Assembly Language Programming–Simple Examples–Architectural Support for Operating systems.

UNIT V	ARM ORGANIZATION	9

3-Stage Pipeline ARM Organization–5-Stage Pipeline ARM Organization–ARM Instruction Execution- ARM Implementation– ARM Instruction Set– ARM coprocessor interface– Architectural support for High Level Languages – Embedded ARM Applications.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to

CO1: Outline the architecture and programming in PIC microcontrollers.
CO2: Summarize the embedded peripheral devices for data communication.
CO3: Interpret the recent trends in embedded firmware environment.
CO4: Explain the basic circuits for ARM microcontroller.
CO5: Illustrate the assembly and software program of ARM microcontrollers.

TEXT BOOKS:

1. Peatman,J.B., "Design with PIC Micro Controllers" 3rd Edition, Pearson Education, 2004.
2. Rajkamal, "Embedded System-Architecture, Programming Design", 1st Edition, McGraw Hill, 2013.
3. Furber,S., "ARM System on Chip Architecture" , 1st Edition, Addison Wesley trade Computer Publishers, 2000.
4. Santul Bisht , "ARM processor" , 1st Edition, LAP LAMBERT Academic Publishing ,

2012.

REFERENCES

1. Mazidi M.A."PIC Microcontroller", Rollin McKinley, Danny causey, 1st Edition, Prentice Hall of India, 2007.
2. Douglas V. Hall, "Microprocessors & Interfacing", 3rd Edition, McGraw Hill Higher Education, 2017.
3. Nicolas K. Haddad, "Microcontroller System Design Using PIC18F Processors", 1st Edition, IGI Global Publications, 2017.
4. Joseph Yiu, "The Definitive Guide to ARM, Cortex,M3 and Cortex, M4 Processors", 2nd Edition, Newnes, imprint of Elsevier, 2010.

21PEE18	REAL TIME OPERATING SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To explain the fundamentals of interaction of OS with a computer and user computation.
- To illustrate the fundamental concepts of real time operating systems (RTOS).
- To summarize the programming logic of modeling process based on range of OS features
- To compare the types and functionalities in commercial OS application development using RTOS
- To outline the embedded operating systems.

UNIT I	REVIEW OF OPERATING SYSTEMS	9

Basic Principles - Operating System structures – System Calls – Files – Processes – Design and Implementation of processes – Communication between processes – Introduction to Distributed operating system – issues in distributed system: states, events, clocks.

UNIT II	OVERVIEW OF RTOS	9

RTOS Task and Task state –Multithreaded Preemptive scheduler- Process Synchronization- Message queues– Mail boxes -pipes – Critical section – Semaphores – Classical synchronization problem – Deadlocks.

UNIT III	REAL TIME MODELS AND LANGUAGES	9

Event Based – Process Based and Graph based Models – Real Time Languages – RTOS Tasks – RT scheduling - Interrupt processing – Synchronization – Control Blocks – Memory Requirements.

UNIT IV	REAL TIME KERNEL	9

Principles – Design issues – RTOS Porting to a Target – Comparison and Basic study of various RTOS like – VX works – Linux supportive RTOS – C Executive.

UNIT V	INTRODUCTION TO EMBEDDED OS	9

Discussions on Basics of Linux supportive RTOS – uCOS-C Executive for development of RTOS Application –introduction to Android Environment - Stack – Android User Interface.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Summarize the real-time scheduling and schedulable analysis.
CO2: Compare theoretical and practical knowledge of RTOS.
CO3: Explain the multitasking techniques in real time systems.

CO4: Interpret the fundamental concepts of real-time operating systems.
CO5: Illustrate the employable and entrepreneurship capacity in embedded systems design.

TEXT BOOKS:

1. Silberschatz, Galvin, Gagne "Operating System Concepts",6th Edition, John Wiley,2003.
2. Charles Crowley, "Operating Systems-A Design Oriented approach", 1st Edition, McGraw Hill,1997
3. Karim Yaghmour, "Building Embedded Linux System", 1st Edition, O'Reilly Publication, 2003.
4. C.M. Krishna, Kang, G.Shin, "Real Time Systems", 3rd Edition, McGraw Hill, 1997.

REFERENCES

1. Marko Gargenta, "Learning Android", 1st Edition, O'Reilly Publications, 2011.
2. Herma K., "Real Time Systems – Design for distributed Embedded Applications", 2nd Edition, Kluwer Academic Publishers, 1997.
3. Corbet Rubini, Kroah-Hartman, "Linux Device Drivers", 1st Edition, O'Reilly Publications, 2016.
4. Mukesh Sighal and N G Shi "Advanced Concepts in Operating System", 2nd Edition, McGraw Hill, 2000.

21PEE19	PERVASIVE DEVICES AND TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To explain the fundamentals of wireless sensor devices.
- To summarize the WSN processor and its functions in networking
- To outline the concept of wireless network communication
- To illustrate the concept of sensor network protocols.
- To interpret the wireless networking devices for various protocols

UNIT I	WIRELESS SENSOR DEVICES AND NETWORKING	9

Challenges for Wireless Sensor Networks- Characteristic requirements for WSN ,WSN vs Adhoc Networks - introduction to Sensor node networking with any Commercially available sensor nodes –Physical layer and transceiver design considerations in WSNs, -Applications of sensor networks.

UNIT II	BUILDING PERVASIVE SENSOR NETWORK	9

Single-Node Architecture - Hardware Components, constraints & challenges in resources- Energy Consumption of Sensor Nodes, Operating Systems for Wireless Sensor Networks – Introduction -Operating System Design Issues - Network Architecture -Sensor Network Scenarios.

UNIT III	WIRELESS TECHNOLOGY	9

Constructional features – Rotary and Linear SRM - Principle of operation – Torque production – Steady state performance prediction- Analytical method -Power Converters and their controllers – Methods of Rotor position sensing – Sensor less operation – Characteristics and Closed loop control – Applications.

UNIT IV	OVERVIEW OF SENSOR NETWORK PROTOCOLS	9

Introduction to fundamentals of Wireless sensor network MAC Protocols - Low duty cycle protocols

and wakeup concepts - Contention-based protocols - Schedule-based protocols - IEEE 802.15.4MAC protocol- Energy usage profile.

UNIT V	WIRELESS NETWORKING OF DEVICES	9

Classification of Wireless Networking of Devices, introduction to RF WPAN 802.15.1 & Bluetooth -protocol stack, frame, link manager layer –Bluetooth piconet–application.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Outline the fundamentals of wireless sensor devices and network.
CO2: Explain the concept of building pervasive sensor network.
CO3: Interpret the basics of wireless technology for various protocols.
CO4: Compare various sensor network protocols
CO5: Summarize the wireless networking devices

TEXT BOOKS:

5. HolgerKarl, AndreasWillig, "Protocols & Architectures for WSN", 1st Edition, John Wiley, 2012.
6. Mark Ciampa, Jorge Olenewa, "Wireless Communications", 2nd Edition, Cengage Learning, 2009.
7. Frank Adelstein, Sandeep K.S Gupta Etal, "Fundamentals of Mobile & Pervasive Computing", 1st Edition, Tata McGraw Hill Publications,2010.
8. Jaganathan Sarangapani, "Wireless AdHoc & Sensor N/Ws-Protocols and Control", 2nd Edition, CRC press, 2007.

REFERENCES

1. Natalia Olifer and Victor Olifer, "Computer Networks principles, technologies and protocols for network design", 1st Edition, Wiley, 2015.
2. William Stallings, "Wireless communications and Networks", 2nd Edition PHI/Pearson Education, 2002.
3. Mullet, "Introduction to wireless telecommunications systems and networks", 1st Edition, Cengage learning, 2010.
4. Feng Zhao & Leonidas J. Guibas, "Wireless Sensor Networks- An Information Processing Approach", 2nd Edition, John Wiley,2012.

21PEE20	EMBEDDED LINUX FOR IoT	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To illustrate the fundamentals of Linux Operating system, its basic commands and shell programming
- To outline the history of embedded Linux and basics of GNU Cross Platform Tool Chain.
- To summarize different types of architecture for Embedded Linux
- To explain the concept of configuring kernel using the cross-platform tool chain.
- To interpret drivers for LINUX platforms familiarizing the concepts

UNIT I	FUNDAMENTALS OF LINUX	9

Basic Linux System Concepts: Working with Files and Directories - Introduction to Linux File system -Working with Partitions and File systems - Understanding Linux Permissions; Using Command LineTools: Executing Commands from the Command Line - Getting to a Shell -

Popular Command-Line Commands - Working with the Bash Shell.		
UNIT II	**VARIOUS DISTRIBUTIONS AND CROSS PLATFORM TOOL CHAIN**	**9**
Introduction - History of Embedded Linux - Embedded Linux versus Desktop Linux - Commercial Embedded Linux Distribution - Choosing a distribution - Embedded Linux Distributions – Architecture of Embedded Linux - Linux Kernel Architecture - Porting Roadmap - GNU Cross Platform Toolchain.		
UNIT III	**HOST/ TARGET SETUP AND OVERALL ARCHITECTURE**	**9**
Real Life Embedded Linux Systems - Design and Implementation Methodology - Types of Host/Target Development Setups - Types of Host/Target Debug Setups - Generic Architecture of an Embedded Linux System - System Startup - Types of Boot Configurations - System Memory Layout – Processor Architectures - Buses and Interfaces - I/O – Storage.		
UNIT IV	**KERNEL CONFIGURATION**	**9**
A Practical Project Workspace - GNU Cross-Platform Development Tool chain - C Library Alternatives - Other Programming Languages - Eclipse: An Integrated Development Environment – Terminal Emulators - Selecting a Kernel - Configuring the Kernel - Compiling the Kernel - Installing the Kernel -Basic Root File system Structure - Libraries - Kernel Modules.		
UNIT V	**LINUX DRIVERS**	**9**
Introduction in to basics on Linux drivers, introduction to GNU cross platform Tool chain- Case study on programming one serial driver for developing application using Linux Driver.		
		TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Outline the Linux desktop and GNU tool chain with Eclipse IDE
CO2: Interpret the cross compiler Linux kernel in distribution platform.
CO3: Summarize the applications of the Linux kernel in RTOS.
CO4: Illustrate about distributions and cross platform tool chain.
CO5: Explain the application of Linux Drivers.

TEXT BOOKS:

1. Karim Yaghmour, Jon Masters, Gilad Ben-Yossef and Philippe Gerum, "Building Embedded Linux Systems", 2nd Edition, SPD -O'Reilly Publications, 2008.
2. P.Raghavan, Amol Lad, Sriram Neelakandan, "Embedded Linux System Design & Development", 3rd Edition, Auerbach Publications, 2012.
3. Karim Yaghmour, "Building Embedded Linux System" , 2nd Edition, O'Reilly Publication, 2003.
4. Raj Kamal, "Embedded Systems- Architecture, Programming and Design" 1st Edition, Tata McGraw Hill, 2006.

REFERENCES

1. William Von Hagen, "Ubuntu Linux Bible", 3rd Edition, Wiley Publishing Inc., 2010.
2. Jonathan Corbet, Alessandro Rubini and Greg Kroah-Hartman, "Linux Device Drivers", 3rd Edition, SPD -O'Reilly Publications, 2011.
3. Robert Love, "Linux System Programming", 1st Edition, SPD -O'Reilly Publications, 2010.
4. Corbet Rubini, Kroah-Hartman, "Linux Device Drivers", 1st Edition, O'Reilly

Publications, 2016.

21PEE21	EMBEDDED AUTOMOTIVE SYSTEM	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To outline the fundamentals of embedded communication process.
- To explain the fundamentals of wireless embedded networking
- To demonstrate the automation in instrumentation
- To illustrate the measurement and control of electrical apparatus
- To interpret the communication for large electrical system automation

UNIT I	EMBEDDED PROCESS COMMUNICATION WITH INSTRUMENT BUS	9

Embedded Networking: Introduction – Cluster of Instruments in System: introduction to bus protocols,
connectors, Bus Architecture & Interfacing of external instruments to – RS 232C,RS – 422, RS 485
and USB standards – embedded ethernet – MOD bus and CAN bus.

UNIT II	WIRELESS EMBEDDED NETWORKING	9

Wireless sensor networks – Introduction – Sensor node architecture – Commercially available sensor
nodes -Network Topology –Localization –Time Synchronization - Energy efficient MAC protocols –
SMAC –Energy efficient and robust routing – Data Centric routing Applications of sensor networks;
Applications.

UNIT III	BUILDING SYSTEM AUTOMATION	9

Concept of Microcontroller based & PC based data acquisition – Concept of Virtual Instrumentation -Programming Environment to build a Virtual Instrumentation, Building system automation with graphical user interface programming-Programmable Logic Controllers-Introduction-Ladder &Functional Block programming.

UNIT IV	EMBEDDED MEASUREMENT AND CONTROL	9

Sensor Types & Characteristics: Sensing Voltage, Current, flux, Torque, Position, Proximity, Force, Data acquisition & Display system- Signal conditioning circuit design- computers/ embedded processor interfacing circuit -design automation and protection of electrical appliances.

UNIT V	ELECTRICAL SYSTEM AUTOMATION	9

Data Acquisition, Monitoring, Communication, Event Processing, and Polling Principles, SCADA system principles – outage management– Decision support application for substation automation, extended control feeder automation, Performance measure and response time.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Explain the fundamentals of embedded communication protocols.
CO2: Outline the wireless embedded networking concepts.
CO3: Illustrate the concepts of building system automation.
CO4: Summarize the various measurement and control methods of electrical apparatus.
CO5: Compare the various communication system automation.

TEXT BOOKS:

1. James Northcote-Green, Robert Wilson,"Control and automation of electrical power distribution systems", 1st Edition, Taylor and Francis, 2006.
2. Krzysztof Iniewski, "Smart Grid, Infrastructure & Networking", 2nd Edition, Tata McGraw Hill Publications, 2012.
3. Robert Faludi, "Building Wireless Sensor Networks", 1stEdition, O'Reilly Publications, 2011.
4. Shih-LinWu, Yu-CheeTseng, "Wireless Ad-Hoc Networking, PAN, LAN, SAN", 2nd Edition, Aurebach Publications, 2012.

REFERENCES

1. Jan Axelson, "Embedded Ethernet and Internet Complete", 2nd Edition, Penram publications, 2003.
2. Bhaskar Krishnamachari, "Networking wireless sensors", 1st Edition, Cambridge press 2005.
3. Robert H. Bishop, "Learning with Lab-View", 1st Edition, Prentice Hall, 2009.
4. Ernest O.Doeblin and Dhanesh N Manik, "Measurements Systems – Application and Design", 5th Edition, Tata McGraw Hill Publications, 2007.

21PEE22	INTERNET OF THINGS IN MEDICINE	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To explain the fundamentals of IoT functional blocks of healthcare systems.
- To summarize various protocols for IoT.
- To illustrate the IoT system using Rasperry Pi/Arduino.
- To outline data analytics for cloud offerings related to IoT in medicine.
- To interpret the real time applications of IoT in health care systems.

UNIT I	FUNDAMENTALS OF IoT	9

Evolution of Internet of Things - Enabling Technologies – IoT Architectures, IoT World Forum (IoTWF) and Alternative IoT models – Simplified IoT Architecture and Core IoT Functional Stack -– Fog, Edge and Cloud in IoT – Functional blocks of an IoT ecosystem in health care systems.

UNIT II	IoT PROTOCOLS	9

IoT Access Technologies: Physical and MAC layers, topology and Security of IEEE Protocols and WAN – Network Layer: IP versions, Constrained Nodes and Constrained Networks – Optimizing IP for IoT: From 6LoWPAN to 6Lo– Application Layer Protocols: CoAP and MQTT.

UNIT III	DESIGN AND DEVELOPMENT OF PROCESSORS	9

Design Methodology - Embedded computing logic - Microcontroller, System on Chips - IoT system building blocks - Arduino - Board details, IDE programming - Raspberry Pi - Interfaces and Raspberry Pi with Python Programming.

UNIT IV	DATA ANALYTICS AND SUPPORTING SERVICES	9

Structured Vs Unstructured Data and Data in Motion Vs Data in Rest –Hadoop Ecosystem for medical emergency management– Apache Kafka, Apache Spark – Edge Streaming Analytics and Network Analytics in Internet of medical things.

UNIT V	APPLICATIONS OF IOT IN MEDICINE	9

NSUM Technique for Diabetes Patients, Healthcare Monitoring system, An IoT Model for Neuro

sensors, A Fuzzy-Based expert System to diagnose Alzheimer's Disease, Secured architecture for IoT enabled Personalized Healthcare Systems, Healthcare Application.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Outline the concepts of IoT and its applications in health care systems.
CO2: Compare various protocols for IoT.
CO3: Summarize the computing methods for the development of processors.
CO4: Explain the data analytics methods in emergency management system.
CO5: Outline the applications of IoT in medicine.

TEXT BOOKS:

5. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry, "IoT Fundamentals: Networking Technologies, Protocols and Use Cases for Internet of Things", 1st Edition,Cisco Press, 2017.
6. Robert Faludi,"Building Wireless Sensor Networks", 1st Edition, O'Reilly Publications, 2011.
7. Raj Kamal, "Embedded Systems- Architecture, Programming and Design", 2nd Edition, Tata McGraw Hill Publications, 2006.
8. Karim Yaghmour, "Building Embedded Linux System", 2nd Edition, O'Reilly Publications,2003.

REFERENCES

1. Arshdeep Bahga, Vijay Madisetti, "Internet of Things – A hands-on approach", 1st Edition, Universities Press, 2015.
2. Olivier Hersent, David Boswarthick, Omar Elloumi , "The Internet of Things – Key Applications and Protocols", 1st Edition, Wiley, 2012.
3. Shih-LinWu,Yu-CheeTseng,"WirelessAd-HocNetworking,PAN,LAN,SAN",2nd Edition, Aurebach Publications,2012.
4. William Stallings, "Wireless communications and Networks", 2nd Edition PHI/Pearson Education, 2002.

21PEE23	SENSORS AND TRANSDUCERS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To explain the concepts of measurement technology.
- To classify the various sensors used to measure displacement and range.
- To summarize the working principle of force and magnetic sensors
- To demonstrate the operation of pressure, temperature sensors
- To outline the fundamentals of signal conditioning, data acquisition and communication systems used in mechatronics system development.

UNIT I	INTRODUCTION	9

Basics of Measurement – Classification of errors – Error analysis – Static and dynamic characteristics of transducers – Performance measures of sensors – Classification of sensors – Sensor calibration techniques – Sensor Output Signal Types-Sensor Modeling.

UNIT II	MOTION, PROXIMITY AND RANGING SENSORS	9

Motion Sensors – Potentiometers, Encoders –Inductive, Capacitive, Linear variable displacement

transducer (LVDT) – Rotary variable displacement transducer (RVDT) –Accelerometer – Global positioning system (GPS), Bluetooth, Range Sensors –Laser Range Sensor (LIDAR).		
UNIT III	**FORCE AND MAGNETIC SENSORS**	**9**
Strain Gauge, Load Cell, Magnetic Sensors –types, principle, requirement and advantages: Magnetoresistive – Hall Effect – Compass, Gyroscope, Inclinometers.		
UNIT IV	**OPTICAL, PRESSURE AND TEMPERATURE SENSORS**	**9**
Photo conductive cell, photo voltaic, Photo resistive, Light dependent resistor (LDR) – Fiber optic sensors – Pressure – Diaphragm, Bellows, Piezoelectric – Tactile sensors, Temperature – IC, Thermistor, Resistance temperature detector (RTD), Thermocouple. Acoustic Sensors – flow and level measurement.		
UNIT V	**SIGNAL CONDITIONING AND DATA ACQUISITION SYSTEMS**	**9**
Amplification – Filtering – Sample and Hold circuits – Data Acquisition: Single channel and multi-channel data acquisition – Data logging - applications - Automobile, Aerospace, Home appliances, Manufacturing, Environmental monitoring.		
	TOTAL: 45 PERIODS	

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Summarize the types, characteristics and errors associated with sensors.
CO2: Demonstrate the operating principles of motion, proximity and ranging sensors.
CO3: Outline the operating principle of force and magnetic sensors.
CO4: Illustrate the working principles of optical, pressure and temperature sensors.
CO5: Interpret the role of data acquisition systems in real time applications.

TEXT BOOKS:

1. Ernest O Doebelin, "Measurement Systems – Applications and Design", 2nd Edition, Tata McGraw- Hill Publications, 2009.
2. Sawney A K and Puneet Sawney, "A Course in Mechanical Measurements and Instrumentation and
Control", 12th Edition, Dhanpat Rai& Co, New Delhi, 2013.
3. Patranabis D, "Sensors and Transducers", 2nd Edition, PHI, New Delhi, 2010.
4. Jacob Fraden , "Handbook of Modern SensorsPhysics, Designs, and Applications", 1st Edition, Springer, New York, 2004.

REFERENCES

1.William C. Dunn ,"Introduction to Instrumentation, Sensors, and Process Control", 1st Edition, Artech
House, Inc, 2006.
2. Randy Frank, "Understanding Smart Sensors", 2nd Edition, Artech House, Inc, 2000.
3. Richard Zurawski, "Industrial Communication Technology Handbook", 2nd Edition, CRC Press, 2015.
4. Waldemar Nawrocki, "Measurement Systems and Sensors", 1st Edition, Artech House Inc, 2005.

VERTICAL IV: ELECTRIC VEHICLE TECHNOLOGY

21PEE24	ELECTRIC VEHICLE ARCHITECTURE	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To outline the concept of electric vehicles.
- To demonstrate the operation of electric vehicle motors
- To explain the architecture of electric vehicle
- To illustrate the management of architecture parameters.
- To summarize acceleration performance parameters.

UNIT I	INTRODUCTION TO ELECTRIC VEHICLES	9

Electric Vehicle – Need - Types – Cost and Emissions – End of life. Electric Vehicle Technology – layouts, cables, components, Controls. Batteries – overview and its types. Battery plug-in and life. Ultra-capacitor, Charging – Methods and Standards. Alternate charging sources – Wireless & Solar

UNIT II	ELECTRIC VEHICLE MOTORS	9

Motors (DC, Induction, BLDC) – Types, Principle, Construction, Control. Electric Drive Trains (EDT) – Series HEDT (Electrical Coupling) – Power Rating Design, Peak Power Source (PPS); Parallel HEDT (Mechanical Coupling) – Torque Coupling and Speed Coupling. Switched Reluctance Motors (SRM) Drives – Basic structure, Drive Convertor, Design.

UNIT III	ARCHITECTURE OF ELECTRIC VEHICLE	9

Introduction-Electric Vehicle Architecture Power Trains – Electric Motor – Battery Pack – Inverters – DC-DC converter – On-board charger – Battery Management System Components

UNIT IV	MANAGEMENT OF VEHICLE ARCHITECTURE PARAMETERS	9

Introduction - Terms and definitions - Development of a vehicle architecture - Current approaches in systems engineering - Approach of parameter management - Application

UNIT V	MODELLING IN PERFORMANCE PARAMETER	9

Modelling Vehicle Acceleration - Acceleration performance parameters, modelling the acceleration of an electric scooter, modelling the acceleration of a small car.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Summarize the layouts, components and charging methods of electric vehicle.
CO2: Illustrate the operation of DC, induction and BLDC motors.
CO3: Outline the electric vehicle architecture.
CO4: Demonstrate the vehicle architecture parameters.
CO5: Interpret the modelling of acceleration for electric vehicle.

TEXT BOOKS:

1. Jack Erjavec and Jeff Arias, "Hybrid, Electric and Fuel Cell Vehicles", 1st Edition, Cengage Learning, 2012.
2. Mehrdad Ehsani, YiminGao, Sebastien E. Gay and Ali Emadi, "Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design", 1st Edition, CRC Press, 2009.
3. James Larminie, John Lowry, "Electric Vehicle Technology Explained", 1stEdition, John Wiley & Sons Ltd, 2003.

4. Beate Muller, Gereon Meyer, "Electric Vehicle Systems Architecture and Standardization Need", 1st Edition, Springer International Publishing Switzerland, 2015.

REFERENCES:

1. Wei Liu, "Hybrid Electric Vehicle System Modeling and Control - General Motors", 1st Edition, John Wiley & Sons, Inc., 2017.
2. Mehrdad Ehsani, Yimin Gao, Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles_ Fundamentals, Theory, and Design, Second Edition", 1st Edition, CRC Press, 2010.
3. Iqbal Husain, "Electric and Hybrid Vehicles- Design Fundamentals", 1st Edition, CRC Press, 2021.
4. James Larminie, John Lowry, "Electric Vehicle Technology Explained", 1st Edition,Wiley, 2012.

21PEE25	ELECTRIC VEHICLE DESIGN, MECHANICS AND CONTROL	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To outline the concepts of electric vehicle
- To explain the architecture design of electric vehicle
- To demonstrate the operation of electric vehicle
- To summarize the controlling mechanism in electric vehicles.
- To illustrate the maintenance and replacement in electric vehicle

UNIT I	INTRODUCTION: ELECTRIC VEHICLE	9

History, Components of Electric Vehicle, Comparison with Internal combustion Engine : Technology, Comparison with Internal combustion Engine: Benefits and Challenges
EV classification and their electrification levels. EV Terminology

UNIT II	ELECTRIC VEHICLE ARCHITECTURE DESIGN	9

Types of Electric Vehicle and components. Electrical protection and system requirement, Photovoltaic solar based EV design, Battery Electric vehicle (BEV).Hybrid electric vehicle (HEV).Plug-in hybrid vehicle (PHEV),Fuel cell electric vehicle (FCEV),Electrification Level of EV, Comparison of fuel vs Electric and solar power, Solar Power operated Electric vehicles

UNIT III	ELECTRIC VEHICLE DYNAMICS	9

Electric components used in electric vehicles. Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives. Configuration and control of Switch Reluctance Motor drives, drive system efficiency.

UNIT IV	VEHICLE CONTROLLERS	9

Power electronics circuits used for control and distribution of electric power in DC-DC, AC-DC, DC-AC converters used for HEV. Fundamental of Drives and Control of EV Using DC motor, Induction Motor, Permanent Magnet Motor, Switched Reluctance Motor, BLDC motor, Design and Sizing of Traction Motors.

UNIT V	MAINTENANCE, REPAIRS AND REPLACEMENT	9

Introduction, Technical information, De-energizing. During work- Maintenance intervals, Repairs affecting other vehicle systems, Inspect high voltage components. Remove and replace- High Voltage Components, Battery back, Low Voltage Components. Re-energizing-results, records

and recommendations,

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Explain the concepts of Internal combustion Engine.
CO2: Summarize the components used in Electric Vehicle.
CO3: Illustrate control of Induction Motor drives in Electric Vehicle.
CO4: Demonstrate the Sizing of Traction Motors
CO5: Outline Re-energizing-results in a vehicle system

TEXT BOOKS:

1. Amir Khajepour, Saber Fallah and Avesta Goodarzi, "Electric and Hybrid Vehicles Technologies, Modelling and Control: A Mechatronic Approach", 1st Edition, John Wiley & Sons Ltd, 2014.
2. Antoni Szumanowski, "Hybrid Electric Power Train Engineering and Technology: Modelling, Control, and Simulation", Book chapter, 1st Edition, IGI Global, 2013.
3. Mehrdad Ehsani, Yimin Gao, Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles Fundamentals, Theory, and Design" 2nd Edition, CRC Press, 2010.
4. James Larminie, John Lowry, "Electric Vehicle Technology Explained", 2nd Edition, John Wiley & Sons Ltd, 2003

REFERENCES:

1. Chris Mi, Abul Masrur & David Wenzhong Gao, "Hybrid electric Vehicle- Principles & Applications with Practical Properties", 1st Edition, Wiley, 2011.
2. James Larminie, John Lowry, "Electric Vehicle Technology", Wiley, 2nd Edition, 2012.
3. Sandeep Dhameja, "Electric Vehicle Battery Systems", 1st Edition, Newnes Publications, 2001.
4. Iqbal Hussein, "Electric and Hybrid Vehicles: Design Fundamentals", 2nd Edition, CRC Press, 2003.

21PEE26	ELECTRIC HYBRID VEHICLES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To illustrate the basic concepts of electric hybrid vehicles.
- To interpret suitable drive scheme for developing an electric hybrid vehicle.
- To outline the basic schemes of electric vehicles and hybrid electric vehicles.
- To explain the energy storage systems and sizing for electric vehicle applications
- To summarize the various communication protocols and technologies used in vehicle networks

UNIT I INTRODUCTION TO HYBRID ELECTRIC VEHICLES **9**

History of hybrid electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, and mathematical models to describe vehicle performance.

UNIT II HYBRID ELECTRICDRIVE-TRAINS **9**

Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis. Electric Drive-trains: Basic

concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis.

UNIT III	ELECTRIC PROPULSION UNIT	9

Introduction to electric components used in hybrid electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.

UNIT IV	DRIVE AND ENERGY STORAGE SYSTEM	9

Introduction to Energy Storage Requirements in Hybrid Electric Vehicles, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices-Sizing the drive system- Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems

UNIT V	ENERGY MANAGEMENT STRATEGIES	9

Introduction to energy management strategies used in hybrid electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies. Case Studies: Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle (BEV).

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Explain the basics of electric and hybrid electric vehicles.

CO2: Illustrate the use of different power electronics devices and electrical machines in hybrid electric vehicles.

CO3: Summarize the various control strategies of special machines used in hybrid electric vehicles.

CO4: Demonstrate different energy storage devices used for hybrid electric vehicles.

CO5: Interpret working of different configurations of electric vehicles and Energy Management strategies in HEVs.

TEXT BOOKS:

1. Tom Denton, "Electric and Hybrid Vehicle", 1st Edition, Newyork, NY, Routledge, Taylor & Francis Group, 2016.
2. Ali Emadi, Mehrdad Ehsani, John M.Miller, "Vehicular Electric Power Systems", Special Indian Edition, Marcel dekker, Inc 2010.
3. Iqbal Hussein, "Electric and Hybrid Vehicles: Design Fundamentals", 2nd Edition, CRC Press, Taylor & Francis Group, 2011.
4. Amir Khajepour, M. Saber Fallah, AvestaGoodarzi, "Electric and Hybrid Vehicles: Technologies, Modeling and Control - A Mechatronic Approach",1st Edition, Wiley, 2014.

REFERENCE BOOKS:

1. Mehrdad Ehsani, YimiGao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, 3rd Edition, CRC Press, 2018.
2. James Larminie, John Lowry, "Electric Vehicle Technology Explained", 1stEdition, Wiley, 2003.
3. A.K.Babu, 'Electric& Hybrid Vehicles', 1st Edition, Khanna Publishing, 2019.
4. Ronald K. Jurgen, "Electric and Hybrid-Electric Vehicles: Batteries", 1st Edition, SAE

International, 2011.

21PEE27	MOTOR AND POWER CONVERTERS FOR ELECTRIC VEHICLES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To outline the characteristics of electric vehicle motors
- To illustrate the controllers with different mode of operation
- To explain the modeling of Induction motor
- To compare the speed control methods used in Induction motor
- To summarize the concepts of EV control with PWM and inverter

UNIT I	EV MOTORS CHARACTERISTICS AND DC MOTOR	9

Requirement of EV motors, Comparison of EV motors, Basics of DC Motor, Torque speed characteristics, DC Motor dynamics, Field Weakening Control, Four quadrant operation

UNIT II	DC MOTOR DYNAMICS & CONTROL	9

Current Loop Control, Speed Control Loop Dynamical System Control: Gain & Phase Margins, PDController, PI Controller, Selecting PI Gain for Speed Controller, PI Controller Design, PI Controllerwith Reference model, Comparison of conventional PI Controller with PI controller with ReferenceModel, 2 DOF Controller with Internal Model Control, Load Torque Observer, Feedback Linearization,Simplified Modeling of Practical Current Loop

UNIT III	INDUCTION MOTOR	9

Rotating Magnetic Field, Basics of Induction motor, Speed-Torque Curve Leakage inductance, circlediagram, current displacement (double cage rotor), line starting, Dynamic modelling of Induction motor

UNIT IV	INDUCTION MOTOR SPEED CONTROL	9

Rotating Magnetic Field, Basics of Induction motor, Speed-Torque Curve Leakage inductance, circlediagram, current displacement (double cage rotor), line starting, Dynamic modelling of Induction motor, Rotor Field oriented control, Stator Field Oriented Control, Field Weakening Control, Variable VoltageVariable Frequency Control

UNIT V	PWM AND INVERTER	9

Sinusoidal PWM, Injection of third order harmonics, Space Vector Modulation, Dead time & compensation, Encoders, Resolvers, R/D Converters, Hall current sensors and current sampling, VoltageModel Estimator, Current Model Estimator, Closed-loop MRAS observer, Sliding Mode Observer.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Interpret the Torque speed Characteristics of DC motor.
CO2: Illustrate the Practical Current Loop Model.
CO3: Show Dynamic modelling of Induction motor.
CO4: Outline frequency control methods in Induction motor.
CO5: Explain Space Vector Modulation.

TEXT BOOKS:

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals", 1St Edition, CRC Press, 2003.
2. AmirKhajepour, Saber Fallah and AvestaGoodarzi, "Electric and Hybrid

VehiclesTechnologies, Modelling and Control: A Mechatronic Approach", 1st Edition, John Wiley & Sons Ltd, 2014.
3. L. Ashok Kumar, S. Albert Alexander, "Power Converters for Electric Vehicles" 1st Edition,CRC Press 2021
4. Monzer Al Sakka, Joeri Van Mierlo and Hamid Gualous, "DC/DC Converters for Electric Vehicles" Kindle Edition, Intech Open, 2011

REFERENCES:

1. Mehrdad Ehsani, YimiGao, Sebastian Longo, Kambiz Ebrahimi, "Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design", 3rd Edition, CRC Press, 2018.
2. Seref Soylu, "Electric Vehicles: Modelling and Simulations", Edited Volume, kindle Edition, Intech Open,2011
3. Kwang Hee Nam, " AC Motor Control and Electrical Vehicle Applications", 1st Edition, CRC Press, 2017
4. Surajit Das Barman , Abrar Hussain , Toufiq Ahmed, "Speed Control of DC Motor Using PWM Technique", Kindle Edition, Lambert Publications, 2012

21PEE28	ELECTRIC VEHICLE CHARGING SYSTEM	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To summarize the battery parameters used in EV charging
- To explain Lead acid and Nickel based batteries
- To illustrate sodium, lithium and metal air batteries
- To demonstrate charging infrastructure of batteries
- To outline battery charges for EV charging

UNIT I	BATTERY PARAMETERS	9

Cell and battery voltages, Charge (or Amphour) capacity, Energy stored, Energy density, Specific power, Amphour (or charge) efficiency, Energy efficiency, Self-discharge rates, Battery geometry, Batterytemperature, heating and cooling needs, Battery life and number of deep cycles

UNIT II	EV BATTERIES	9

Lead Acid Batteries: Lead acid battery basics, Special characteristics of lead acid batteries, Battery life and maintenance, Battery charging, Summary Nickel-based Batteries: Introduction, Nickel cadmium, Nickel metal hydride batteries

UNIT III	SODIUM, LITHIUM AND METAL AIR BATTERIES	9

Sodium-based Batteries: Introduction, Sodium sulphur batteries, Sodium metal chloride (Zebra) batteriesLithium Batteries: Introduction, The lithium polymer battery, The lithium ion battery Metal Air Batteries: Introduction, The aluminum air battery, The zinc air battery

UNIT IV	CHARGING INFRASTRUCTURE	9

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

UNIT V	EV CHARGING	9

Battery Chargers: Charge equalisation, Conductive (Basic charger circuits, Microprocessor based chargercircuit. Arrangement of an off-board conductive charger, Standard power levels of

conductive chargersInductive (Principle of inductive charging, Soft-switching power converter for inductive charging),Battery indication methods

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Explain the heating and cooling need in battery.
CO2: Illustrate the Battery charging methods.
CO3: Compare the different types of batteries.
CO4: Model the Battery Swapping Station.
CO5: Summarize the Standard power levels of conductive chargers.

TEXT BOOKS:

1. Husain, I. "Electric and Hybrid Vehicles" Boca Raton, 2nd Edition, CRC Press, 2010.
2. James Larminie, John Lowry, "Electric Vehicle Technology Explained", 2nd Edition, John Wiley & Sons Ltd, 2003.
3. C.C Chan, K.T Chau, "Modern Electric Vehicle Technology", 1st Edition, Oxford University Press Inc., New York 2001.
4. Guangjin Zhao, "Reuse and Recycling of Lithium-Ion Power Batteries", 1st Edition, John Wiley & Sons. 2017.

REFERENCES:

5. Arno Kwade, Jan Diekmann, "Recycling of Lithium-Ion Batteries: The LithoRec Way", 1st Edition, Springer, 2018.
6. Ibrahim Dinçer, Halil S. Hamut and Nader Javani, "Thermal Management of Electric Vehicle Battery Systems", 1stEdition, JohnWiley& Sons Ltd., 2016.
7. G. Pistoia, J.P. Wiaux, S.P. Wolsky, "Used Battery Collection and Recycling", 1st Edition, Elsevier, 2001.
8. T R Crompton, "Battery Reference Book",3rd Edition, Newnes- Reed Educational and Professional Publishing Ltd., 2000.

21PEE29	TESTING OF ELECTRIC VEHICLES	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To explain about the testing of electric vehicle.
- To summarize the static testing of vehicle
- To illustrate the dynamics testing of vehicle
- To interpret the vehicle component testing.
- To demonstrate the retro fitment and charging station.

UNIT I INTRODUCTION **9**

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, various Parameters, Instruments and Types of test tracks, Hardware in The Loop (HIL) concepts for EV/HEVs.

UNIT II STATIC TESTING OF VEHICLE **9**

Photographs, CMVR physical verification, Tyre Tread Depth Test, Vehicle Weightment, Horn installation, Rear view mirror installation, Tell Tales, External Projection, Wheel Guard, Arrangement of Foot Controls for M1 Vehicle, Angle & Dimensions Measurement of Vehicle,

The Requirement of Temporary Cabin For Drive– Away – Chassis, Electric vehicle – Safety Norms, Energy consumption and Power test.		
UNIT III	**DYNAMICS TESTING OF VEHICLE**	**9**
Hood Latch, Gradeability, Pass-by Noise, Interior Noise, Turning Circle Diameter & Turning Clearance Circle Diameter, Steering Effort, Constant Speed Fuel Consumption, Cooling Performance, Speedo-meter Calibration, Range Test, Maximum Speed, Acceleration Test, Coast-down test, Brakes Performance ABS Test, Broad band / Narrow band EMI Test, Electric vehicle – Range Test.		
UNIT IV	**VEHICLE COMPONENT TESTING**	**9**
Horn Testing, Safety Glasses Test: Windscreen laminated and toughened safety glass, Rear View Mirror Test, Hydraulic Brakes Hoses Fuel Tank Test: Metallic & Plastic, Hinges and Latches Test, Tyre & Wheel Rim Test, Bumper Impact Test, Side Door Intrusion, Crash test with dummies, Demist test, Defrost Test, Interior Fittings, Steering Impact test (GVW<1500 kg), Body block test, Head form test, Driver Field OfVision, Safety belt assemblies, Safety belt anchorages, Seat anchorages & head restraints test, AirbagTest, Accelerator Control System, Motor power, Safety Requirements of Traction Batteries, EMI-EMC(CI, BCI, RE,RI and CTE).		
UNIT V	**TESTS FOR HYBRID ELECTRIC VEHICLES, RETROFITMENT AND CHARGING STATION**	**9**
Hybrid Electric Vehicles Tests (M and N category), Tests for Hybrid Electric System Intended for Retrofitment on Vehicles of M and N Category (GVW < 3500 kg), Test for Electric Propulsion kit intended for Conversion, Test for Electric Vehicle Conductive AC Charging System, and Test for Electric vehicle conductive DC charging system.		
		TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Illustrate specification and classification of vehicles.
CO2: Interpret the various testing of EV.
CO3: Demonstrate the various dynamic tests of EV
CO4: Summarize the various component testing of EV.
CO5: Explain the various hybrid electric vehicle testing.

TEXT BOOKS:

1. Michael Plint& Anthony Martyr, "Engine Testing & Practice", 3rd Edition, Butterworth Heinmenn, 2007
2. Richard W. Carlson, "Testing and Analysis of Three Plug-in Hybrid Electric Vehicles", 1st Edition, SAE International,2007
3. M. Pozzi, "Testing of Electric Vehicles", 1st Edition, The University of Michigan,2016
4. Ronald K. Jurgen, "Electric and Hybrid-electric Vehicles", 1st Edition, SAE International,2011.

REFERENCES:

1. Bosch Automotive Handbook, 7thEdition,Robert Bosch, 2007.
2. Li Zhai, "Electromagnetic Compatibility of Electric Vehicle", 1st Edition, Springer Singapore,2021
3. Bruno Scrosati, JurgenGarche, Werner Tillmetz, "Advances in Battery Technologies for Electric Vehicles", 1st Edition, Elsevier Science,2015.
4. RuiXiong, "Battery Management Algorithm for Electric Vehicles", 1st Edition, Springer

Singapore,2019.

21PEE30	RENEWABLE ENERGY ENGINEERING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To summarize renewable energy sources.
- To illustrate the components and working principle of wind power plants.
- To explain the various types of solar thermal and solar PV systems.
- To interpret the biomass conversion and mini/micro hydro power plant.
- To outline the other types of renewable energy sources.

UNIT I	RENEWABLE ENERGY SOURCES	9

Environmental consequences of fossil fuel use, Importance of renewable sources of energy, Sustainable Design and development, Types of RE sources, Limitations of RE sources, Present Indian and international energy scenario of conventional and RE sources.

UNIT II	WIND ENERGY	9

Power in the Wind – Types of Wind Power Plants(WPPs)–Components of WPPs-Working of WPPs- Siting of WPPs-Grid integration issues of WPPs.

UNIT III	SOLAR PV AND THERMAL SYSTEMS	9

Solar Radiation, Radiation Measurement, Solar Thermal Power Plant, Central Receiver Power Plants, Solar Ponds.- Thermal Energy storage system with PCM- Solar Photovoltaic systems : Basic Principle of SPV conversion – Types of PV Systems- Types of Solar Cells, Photovoltaic cell concepts: Cell, module, array ,PV Module I-V Characteristics, Efficiency & Quality of the Cell, series and parallel connections, maximum power point tracking, Applications.

UNIT IV	BIOMASS ENERGY	9

Introduction-Bio mass resources –Energy from Bio mass: conversion processes-Biomass Cogeneration-Environmental Benefits. Geothermal Energy: Basics, Direct Use, Geothermal Electricity. Mini/micro hydro power: Classification of hydropower schemes, Classification of water turbine, Turbine theory, Essential components of hydroelectric system.

UNIT V	OTHER ENERGY SOURCES	9

Tidal Energy: Energy from the tides, Barrage and Non Barrage Tidal power systems. Wave Energy: Energy from waves, wave power devices. Ocean Thermal Energy Conversion (OTEC)- Hydrogen Production and Storage- Fuel cell: Principle of working- various types - construction and applications. Energy Storage System- Hybrid Energy Systems.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Classify the various conventional energy sources
CO2: Illustrate the construction and working of wind power plants
CO3: Explain the knowledge of solar energy systems.
CO4: Interpret the basics of biomass conversion energy.
CO5: Outline the various renewable energy sources and their applications.

TEXT BOOKS:

1. Joshua Earnest, Tore Wizeliu, "Wind Power Plants and Project Development", 1st Edition PHI Learning Pvt.Ltd, New Delhi, 2011.
2. D.P.Kothari, K.C Singal, Rakesh Ranjan "Renewable Energy Sources and Emerging

Technologies", 2nd Edition, PHI Learning Pvt. Ltd, New Delhi, 2013.
3. Scott Grinnell, "Renewable Energy & Sustainable Design", 1st Edition, CENGAGE Learning, USA, 2016.
4. A.K. Mukerjee and Nivedita Thakur, "Photovoltaic Systems: Analysis and Design", 2nd Edition PHI Learning Private Limited, New Delhi, 2011.

REFERENCES

5. Richard A. Dunlap, "Sustainable Energy", 1st Edition, Cengage Learning India Private Limited, Delhi, 2015.
6. Chetan Singh Solanki, "Solar Photovoltaics: Fundamentals, Technologies and Applications", 2nd Edition, PHI Learning Private Limited, New Delhi, 2011
7. Godfrey Boyle, "Renewable Energy", Open University, 2nd Edition, Oxford University Press in association with the Open University, 2004.
8. A. Shunmugalatha, M. Devaki and R. Saranya, "Renewable Energy Systems", 1st Edition Technical Publication, 2020.

VERTICAL V: MODERN CONTROL TECHNOLOGIES

21PEE31	NON LINEAR CONTROL SYSTEM	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To explain state feedback control and state observer
- To illustrate phase plane analysis
- To summarize various function analysis
- To demonstrate the design and function of optimal controller.
- To outline the function of optimal estimator including Kalman Filter

UNIT I	STATE VARIABLE ANALYSIS	9

Introduction to state Model- effect of state Feedback- Necessary and Sufficient Condition for Arbitrary Pole-placement- pole placement Design- design of state Observers- separation principle-servo design: -State Feedback with integral control.

UNIT II	PHASE PLANE ANALYSIS	9

Features of linear and non-linear systems - Common physical non-linearities – Methods of linearization Concept of phase portraits – Singular points – Limit cycles – Construction of phase portraits – Phase plane analysis of linear and non-linear systems – Isocline method.

UNIT III	DESCRIBING FUNCTION ANALYSIS	9

Basic concepts, derivation of describing functions for common non-linearities – Describing function analysis of non-linear systems – limit cycles – Stability of oscillations.

UNIT IV	ANALYSIS OF NONLINEAR SYSTEMS	9

Periodic orbits - limit cycles-Poincare-Bendixson criterion-Bendixson criterion. Existence and uniqueness of solutions, Lipschitz condition.

UNIT V	STABILITY OF NONLINEAR SYSTEMS	9

Stability of Nonlinear Systems - Lyapunov stability - local stability - local linearization and stability in the small- Direct method of Lyapunov - generation of Lyapunov function for linear and nonlinear systems – variable gradient method.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Illustrate concepts of state variables and state model.
CO2: Explain linear and non-linear systems.
CO3: Summarize the concepts of phase plane method.
CO4: Outline the stability analysis by describing function method.
CO5: Demonstrate the function of Optimal state regulator.

TEXT BOOKS:

1. M.Gopal, "Digital Control and State Variable Methods", 4th Edition, McGraw Hill India, 2012
2. K. Ogata, "Modern Control Engineering", 5thEdition, Pearson publication, 2012
3. K. P. Mohandas, "Modern Control Engineering", 2nd Edition, Sanguine Technical Publishers, 2006
4. D.S.Naidu, "Optimal Control Systems" 1st Edition, CRC Press, 2009.

REFERENCES

1. M.Gopal, "Modern Control System Theory", 3rdEdition, New Age International Publishers, 2014.

2. William S Levine, "Control System Fundamentals", 1st Edition, The Control Handbook, CRC Press, 2011.
3. H. Marquez, 'Nonlinear Control Systems", Analysis and Design, 1st Edition Wiley, 2003.
4. A. Isidori, "Nonlinear Control Systems", 3rd Edition, Springer, 1995.

21PEE32	LOGIC AND DISTRIBUTED CONTROL SYSTEM	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To outline the overview of automation technologies such as PLCs, SCADA and DCS used in industries.
- To summarize the basics of PLC Programming with ladder logic.
- To apply PLC controlled sequential process in PLC programming languages.
- To illustrate hardware architecture and types of distributed control system.
- To explain some of the advanced principles those are evolving for present and future automation.

UNIT I	PLC & SCADA	9

PLC: Evolutions of PLCs – Programmable Controllers – Architecture, I/O modules – Comparative study of Industrial PLCs. SCADA: Remote terminal units- Master station - Communication architectures.

UNIT II	BASICS OF PLC PROGRAMMING(LADDER)	9

Basics of PLC programming – Ladder Logic – Relay type instructions – Timer/Counter instructions – Program control instructions – Data manipulation and math instructions – Programming Examples.

UNIT III	PLC PROGRAMMING (OTHER LANGUAGES)	9

Functional block programming - Sequential function chart – Instruction list – Structured text programming – PLC controlled sequential Process Examples.

UNIT IV	DISTRIBUTED CONTROL SYSTEM	9

DCS: Evolution & types – Hardware architecture – Field control station – Interfacing of conventional and smart field devices (HART and FF enabled) with DCS Controller – Communication modules – Operator and Engineering Human interface stations – Study of any one DCS available in market.

UNIT V	ADVANCED TOPICS IN AUTOMATION	9

Introduction to Networked Control systems – Plant wide control – Internet of things – Cloud based Automation – OLE for Process Control – Safety PLC – Case studies: PLC - SCADA - DCS.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Explain the important components such as PLC, SCADA, DCS, I/O modules and field devices of an industrial automation system.
CO2: Outline the various instructions in PLC programming with ladder logic
CO3: Develop PLC program in different languages for industrial sequential applications.
CO4: Show the most appropriate automation technologies for a given application.
CO5: Infer to gain knowledge on the recent developments in industrial automation.

TEXT BOOKS:

1. F.D. Petruzella, "Programmable Logic Controllers", 3rd Edition, Tata Mc-Graw Hill, 2010

2. Michael P. Lukas, "Distributed Control Systems: Their Evaluation and Design" , 1st Edition Van Nostrand Reinhold Co., 1986
3. D. Popovic and V.P.Bhatkar,' Distributed computer control for industrial Automation', 1st Edition, Marcel Dekker, Inc., Newyork, 1990.

REFERENCES

1. Clarke, G., Reynders, D. and Wright, E., "Practical Modern SCADA Protocols: DNP3,4. 60870.5 and Related Systems", 1st Edition, Newnes, 2004.
2. Hughes, T.A., "Programmable Logic Controllers: Resources for Measurements and Control Series", 3rd Edition, ISA Press, 2004.
3. McMillan, G.K., "Process/Industrial Instrument and Controls Handbook", 5th Edition, McGraw- Hill handbook, New York, 1999.
4. NPTEL Notes on, "Programmable Logic Control System" by Department of Electrical Engg., IIT Kharagpur.

21PEE33	PROCESS MODELING AND SIMULATION	L	T	P	C
		3	0	0	3

COURSEOBJECTIVES:

- To classify the mathematical models of simulation
- To interpret the linear and non-linear algebraic equations of Steady State Lumped systems.
- To explain the simulation of closed loop systems.
- To outline the concepts of Steady State Distributed System.
- To illustrate Unsteady State Distributed System & Other Modeling Approaches.

UNIT I	INTRODUCTIONTO MODELING AND SIMULATION	9

Introduction to modeling and simulation, classification of mathematical models, conservation equations and auxiliary relations.

UNIT II	STEADY STATE LUMPED SYSTEMS	9

Degree of freedom analysis, single and network of process units, systems yielding linear and nonlinear algebraic equations, flow sheeting – sequential modular and equation oriented approach, tearing, partitioning and precedence ordering, solution of linear and non-linear algebraic equations.

UNIT III	UNSTEADY STATE LUMPED SYSTEMS	9

Analysis of liquid level tank, gravity flow tank, jacketed stirred tank heater, reactors, flash and distillation column, solution of ODE initial value problems, matrix differential equations, simulation of closed loop systems.

UNIT IV	STEADY STATE DISTRIBUTED SYSTEM	9

Analysis of compressible flow, heat exchanger, packed columns, plug flow reactor, solution of ODE boundary value problems.

UNIT V	UNSTEADY STATE DISTRIBUTED SYSTEM & OTHER MODELING APPROACHES	9

Analysis laminar flow in pipe, sedimentation, boundary layer flow, conduction, heat exchanger, heat transfer in packed bed, diffusion, packed bed adsorption, plug flow reactor. Empirical modeling, parameter estimation, population balance and stochastic modeling.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Explain the process models based on conservation principles.

CO2: Summarize the numerical methods for the solution of linear and non-linear algebraic equations of Steady State Lumped systems.

CO3: Outline the process data and computational technique.

CO4: Interpret the Steady State Distributed System.

CO5: Illustrate the steady State Distributed System & Other Modeling Approaches.

TEXT BOOKS:

1. Ramirez. W," Computational Methods in Process Simulation", 2nd Edition, Butterworths Publishers, New York, 2000.
2. Luyben, W.L., "Process Modeling Simulation and Control", 2nd Edition, McGraw-Hill Book Co., 1990.
3. C ´esar de Prada Constantinos Pantelides Jos ´e Luis Pitarch , "Process Modeling and Simulation", 1stEdition, MDPI Publication, 2019.
4. Bharat A. Bhanvase, Rajendra P. Ugwekar, "Process Modeling, Simulation, and environmental Applications in Chemical Engineering", 1stEdition,Apple Academic Press, 2021.

REFERENCES:

1. Felder, R. M. and Rousseau, R. W., "Elementary Principles of Chemical Processes", 1st Edition, John Wiley, 2000.
2. Franks, R. G. E., "Mathematical Modeling in Chemical Engineering ", 1st Edition, John Wiley, 1967.
3. Amiya K. Jana, "Process Simulation and Control Using ASPEN", 2nd Edition, PHI Learning Ltd, 2012.
4. Amiya K. Jana, "Chemical Process Modeling and Computer Simulation" 2nd Edition, PHI Learning Ltd, 2012.

21PEE34	COMPUTER CONTROL OF PROCESSES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To interpret the linear time invariant system in discrete State Space form.
- To explain about Digital controllers.
- To summarize the techniques of DAS, DDC, AI and SCADA.
- To Illustrate the System identification techniques.
- To outline about Multi-loop and multivariable controller for multivariable system.

UNIT I	ANALYSIS OF DISCRETE DATA SYSTEM	9

State-space representation of discrete data systems: Selection of sampling process – Selection of sampling period – Review of z-transform – Pulse transfer function – Modified z-transform - Stability of discrete data system – Jury's stability test.

UNIT II	DESIGN OF DIGITAL CONTROLLER	9

Digital PID – Position and velocity form – Deadbeat's algorithm – Dahlin's algorithm – Kalman's algorithm - Pole placement controller – Predictive controller.

UNIT III	COMPUTER AS A CONTROLLER	9

Basic building blocks of computer control system – Data acquisition systems – SCADA – Direct digital control – Introduction to AI and expert control system – Case study - Design of

computerized multi loop controller.		
UNIT IV	**SYSTEM IDENTIFICATION**	**9**
Non Parametric methods: Transient Analysis, Frequency analysis, Correlation analysis, Spectral analysis. Parametric methods: Least Square method, Recursive least square method.		
UNIT V	**MULTI LOOP REGULATORY CONTROL**	**9**
Multi-Loop Control: Introduction, Process Interaction, Pairing of Input and Outputs, Relative Gain Array (RGA) - Properties and Application of RGA, Multi-loop PID Controller – Decoupler.		
	TOTAL: 45 PERIODS	

COURSEOUTCOMES: At the end of the course, learners will be able to:

CO1: Explain the analysis of discrete data system.
CO2: Summarize various digital control algorithms.
CO3: Classify the techniques of DAS, DDC, AI and SCADA.
CO4: Outline the models from Input-Output data.
CO5: Illustrate Multi-loop and multivariable controller for multivariable system.

TEXT BOOKS

1. P.B. Deshpande, and R.H.Ash, "Computer Process Control", 1st Edition, ISA Publication, USA, 1995.
2. SigurdSkogestad, Ian Postlethwaite, "Multivariable Feedback Control: Analysis and Design", 1st Edition, John Wiley and Sons, 2005.
3. Nagaraj B, "Computer Control of Process", Anuradha Agencies, 1st Edition, Technical Publishers, 2018.
3. John Peschon, Lucas Pun, Sanjay K.Mitter , "Computer Process Control" , 1st Edition, MIT Publications,2007.

REFERENCES

1.C.M.Houpis, G.B.Lamount, "Digital Control Systems Theory, Hardware and Software", International Student Edition, McGraw Hill Book Co., 1985.
2. G. Stephanoupoulis, "Chemical Process Control", 1st Edition, Prentice Hall of India, New Delhi, 1990.
3. Singh, "Computer Aided Process Control", 1st Edition, Prentice Hall of India, 2004.
4.M. Chidambaram, "Computer Control of Processes", 1st Edition, Narosa Publication, 2006.

21PEE35	**SYSTEM MODELLING AND IDENTIFICATION**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To illustrate the mathematical modeling of systems.
- To explain systems by their behavior using parametric identification methods using online and offline data.
- To demonstrate systems by their behavior using nonparametric identification methods using online and offline data.
- To outline the data using parametric and recursive estimation methods.
- To summarize the case studies on electromechanical and process control systems.

UNIT I	**NONPARAMETRIC IDENTIFICATION**	**9**
Transient and frequency analysis methods, impulse and step response methods, correlation method, spectral analysis.		

UNIT II	PARAMETRIC INDENTIFICATION	9
Steps in identification process, determining model structure and dimension, Linear and nonlinear model structures (ARX, ARMAX, Box-Jenkins, FIR, Output Error models), Input signals: commonly used signals, spectral properties, and persistent excitation, Residual analysis for determining adequacy of the estimated models.		
UNIT III	**MODEL REFERENCE ADAPTIVE CONTROLLER**	**9**
The MIT rule – Lyapunov theory – Design of model reference adaptive controller using MIT rule and Lyapunov theory – Relation between model reference adaptive controller and self-tuning regulator.		
UNIT IV	**PARAMETRIC ESTIMATION**	**9**
Linear regression, least square estimation, statistical analysis of LS methods, Minimizing prediction error- identifiability, bias, Least squares, relation between minimizing the prediction error and the MLE, MAP, Convergence and consistency, asymptotic distribution of parameter estimates, Instrumental Variable Method.		
UNIT V	**CASE STUDIES**	**9**
Electro Mechanical Systems, Process Control Systems using Matlab/Equivalent System Identification Toolbox		
	TOTAL: 45 PERIODS	

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1:Summarize different model structures, parameterization, identifiability, structure determination and order estimation.

CO2: Explain parameter estimation using different identification techniques.

CO3: Interpret the asymptotic distribution of parameter estimates, Instrumental Variable Method.

CO4: Illustrate the accuracy and precision of Recursive Estimation model.

CO5: Compare design choices to arrive at a validated model.

TEXT BOOKS:

1. Jung, L.,"System Identification: Theory for the User", 2nd Edition, Prentice-Hall, 1999.
2. TorstenSoderstrom, PetreStoica, "System Identification", 1st Edition, Prentice Hall International, 1989.
3. Karel J. Keesman, "System Identification, An introduction", 1st Edition, Springer, 2011.
4. Johan Schoukens, "Mastering System Identification in 100 Exercises", 1st Edition, Wiley-IEEE Press, 2012.

REFERENCES

1. Zhu, Y., "Multivariable System Identification for Process Control", 1st Edition, Pergamon publishing, 2001.
2. Landan ID, "System Identification and Control Design," 1st Edition, Prentice Hall, 1990.
3. ArunK.Tangirala, "Principles of System Identification: Theory and Practice", 1st Edition, CRC Press,2014.
4. Rik Pintelon Johan Schoukens, "System Identification", 2nd Edition, Wiley-IEEE Press, 2012.

21PEE36	PROCESS CONTROL	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To illustrate technical terms and nomenclature associated with Process control domain
- To explain sizing of control valves with their characteristics and selection
- To demonstrate an overview of the features associated with Industrial type PID controller
- To compare various PID tuning methods
- To show various types of control schemes such as cascade control, feed forward control and Model Based control schemes

UNIT I	PROCESS MODELLING AND DYNAMICS	9

Need for process control – Mathematical Modeling of Processes: Level, Flow, Pressure and Thermal processes – Continuous and batch processes – Self regulation – Servo and regulatory operations – Lumped and Distributed parameter models – Heat exchanger – CSTR –Linearization of nonlinear systems.

UNIT II	FINAL CONTROL ELEMENTS	9

Actuators: Pneumatic and electric actuators – Control Valve Terminology - Characteristic of Control Valves: Inherent and Installed characteristics - Valve Positioner – Modeling of a Pneumatically Actuated Control Valve – Control Valve Sizing: ISA S 75.01 standard flow equations for sizing Control Valves – Cavitation and flashing – Control Valve selection

UNIT III	CONTROL ACTIONS	9

Characteristic of ON-OFF, Proportional, Single speed floating, Integral and Derivative controllers– P+I, P+D and P+I+D control modes – Practical forms of PID Controller – PID Implementation Issues: Bumpless, Auto/manual Mode transfer, Anti-reset windup Techniques – Direct/reverse action.

UNIT IV	PID CONTROLLER TUNING	9

PID Controller Design Specifications: Criteria based on Time Response and Criteria based Frequency Response - PID Controller Tuning: Z-N and Cohen-Coon methods, Continuous cycling method and Damped oscillation method, optimization methods, Auto tuning – Cascade control – Feed-forward control

UNIT V	MODEL BASED CONTROL SCHEMES	9

Smith Predictor Control Scheme - Internal Model Controller – IMC PID controller – Three element Boiler drum level control - Introduction to Multi-loop Control Schemes – Control Schemes for CSTR, and Heat Exchanger - P&ID diagram

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1:Explain about Process Modelling And Dynamics
CO2:Summarize the operation of final control elements
CO3:Demonstrate the Characteristic of PID controller
CO4:Illustrate the Specifications of PID tuning methods
CO5:Explain Model Based control schemes

TEXT BOOKS:

9. Seborg, D.E., Edgar, T.F. and Mellichamp, D.A., "Process Dynamics and Control", 2nd Edition, Wiley publication, 2003.
10. Bequette, B.W., "Process Control Modeling, Design and Simulation", 2nd Edition, Prentice

Hall of India, 2004.
11. Stephanopoulos, G., "Chemical Process Control An Introduction to Theory and Practice", 1st Edition, Prentice Hall of India, 2005.
12. Johan Schoukens, "Mastering System Identification in 100 Exercises", 1st Edition, Wiley-IEEE Press

REFERENCES

9. Ramesh C. Panda., T.Thyagarajan., "An Introduction to Process Modelling Identification and Control for Engineers", 1st Edition, Narosa Publishing, 2017.
10. Coughanowr D.R., "Process Systems Analysis and Control", 1st Edition, McGraw Hill International, 2004.
11. Curtis D. Johnson, "Process Control Instrumentation Technology", 8th Edition, Pearson, 2006.
12. Considine, D.M., "Process Instruments and Controls Handbook", 2nd Edition, McGraw Hill, 1999.

21PEE37	ROBOTICS AND CONTROL	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To explain the basics of robotics
- To illustrate homogeneous transformation in robots
- To outline kinematic analysis of robots
- To demonstrate the robot machine vision system in robotic motion control.
- To relate independent joint control of robot dynamics

UNIT I	INTRODUCTION TO ROBOTS	9

Types of robots, Degrees of freedom of robots, Robot configurations and concept of workspace, End effectors and Different types of grippers, vacuum and other methods of gripping. Pneumatic, hydraulic and electrical actuators, applications of robots, specifications of different industrial robots.

UNIT II	RIGID MOTION AND HOMOGENEOUS TRANSFORMATION	9

Coordinate frames. Different orientation descriptions. Free vectors. Translations rotations and relative motion, Composition of rotation, rotation with respect to fixed frame and current frame, parameterisation of rotation, Euler Angele, roll, pitch, yaw, axis/angle representation, Homogeneous transformation

UNIT III	FORWARD KINEMATICS	9

Link coordinate frames. Denavit-Hartenberg convention. Assignment, of coordinate frame, Joint and end effector Cartesian space. Calculation of DH parameters and forward kinematic equation of different configuration of manipulator, Planner elbow manipulator, Cylindrical three link, SCARA, Spherical Wrist and other configuration..

UNIT IV	ROBOT MACHINE VISION AND SENSOR	9

Sensors and sensor based system in robotics: Machine vision system, Description, Sensing, Digitizing, Image processing, Analysis and application, Robotic assembly sensors, Intelligent sensors

UNIT V	INDEPENDENT JOINT CONTROL	9

Actuator dynamics, Set point tracking Feed forward control, Drive Train dynamics. Introduction to force control and multivariable control.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Illustrate basic concepts of robot configuration and different methods of gripping.
CO2: Explain Translations rotations and relative motion of robots.
CO3: Relate the forward kinematic equation of different manipulators.
CO4: Show the sensing and image processing by means of robots.
CO5: Summarize the drive train dynamics.

TEXT BOOKS:

1. M.W. Spong, S. Hutchinson, and M. Vidyasagar, "Robot Modeling and Control", 2nd Edition, Wiley publication, 2020.
2. J.J. Craig, "Introduction to Robotics: Mechanics and Control", 4th Edition, Pearson Education, 2017.
3. M.P. Groover, "Industrial Robots: Technology, Programming and applications", 2nd Indian Edition, McGraw Hill, 2012.
4. Kevin M. Lynch, Frank C. Park, "Modern Robotics: Mechanics, Planning, and Control", 1st Edition, Cambridge University Press, 2017.

REFERENCES

1. Etienne Dombre; Wisama Khalil, Somerset, "Robot Manipulators : Modeling, Performance Analysis and Control", 1st Edition, Wiley publications, 2013
2. M.O. Tokhi, A.K.M. Azad, "Flexible robot manipulator: modelling, simulation and control" 2nd Edition, The Institution of Engineering and Technology, 2017.
3. Ashitava Ghosal, "Robotic fundamental Concept and Analysis", 11th impression, Oxford University Press, 2015.
4. Saeed B. Niku, "Introduction to Robotics: Analysis, Control, Applications", 3rd Edition, Wiley publication, 2020

VERTICAL – VI: INDUSTRIAL SYSTEMS

21PEE38	NANOMATERIALS FOR ENERGY HARVESTING APPLICATIONS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To illustrate the various types of energy harvesting and storage applications

- To outline the methods of hydrogen energy generation
- To summarize the key challenges in choosing nanogenerators
- To explain the conventional energy generation techniques
- To show the various nanomaterials used for energy storage

UNIT I	INTRODUCTION	9

Criteria for choosing the nanomaterials for energy harvesting and storage applications, Brief discussion about all types of energy harvesting and storage systems, Solar energy, Nanomaterials used for solar energy, Types of solar energy, Solar thermal and heat transfer fluids with example.

UNIT II	HYDROGEN ENERGY	9

Introduction, Nanomaterials used for hydrogen energy generation, Methods to produce hydrogen energy,Hydrogen production from fossil fuels and biomass, thermo-chemical process, electrolysis, solar and biological, Key Challenges for hydrogen energy generation.

UNIT III	NANOGENERATORS	9

Introduction, Types of Nanogenerators: Piezoelectric, Thermoelectric, Pyro-electric, Electromagnetic, and Triboelectric, Key challenges for choosing nanomaterials for nanogenerators.

UNIT IV	CONVENTIONAL ENERGY GENERATION TECHNIQUES	9

Wind energy, Tidal, Thermal, hydro power generation, Nuclear and geothermal energy-production.

UNIT V	ENERGY STORAGE	9

Nanomaterials used for energy storage, key challenges for energy storage, Solution of key challenges, Type of energy storages: Electrochemical (Batteries), Supercapacitor, Hydrogen storage, Thermal energy storage.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Explain the need for energy harvesting and storage applications
CO2: Outline the various techniques used in hydrogen energy generation
CO3: Summarize the nanogenerators types used for energy generation.
CO4: Interpret the challenges in conventional energy generation techniques
CO5: Classify the various types nanomaterials used for energy storage

TEXT BOOKS:

1. Losito, Onofrio, Mescia, Luciano, Prudenzano, Franceso, "Innovative materials and systems for energy harvesting applications",1st Edition, Engineering Science Reference, IGI Global, 2015.
2. Hyunuk Kim, YonasTadesse, ShashankPriya, "Energy Harvesting Technologies", 1st Edition, Springer, 2009.
3. AlirezaKhaligh, Omer C. Onar, "Energy Harvesting: Solar, Wind, and Ocean Energy Conversion Systems (Energy, Power Electronics, and Machines)",1st Edition, CRC Press,

2009.
4. AlperErturk, Daniel J. Inman, "Piezoelectric Energy Harvesting", 1st Edition, Wiely,2011.

REFERENCES

1. Niell Elvin, AlperErturk, "Advances in Energy Harvesting Methods", 1st Edition, Springer-Verlag New York, 2013.
2. Dibin Zhu, Steve Beeby, "Energy Harvesting Systems: Principles, Modeling and Applications", 1st Edition, Springer-Verlag New York, 2011.
3. ZekaiŞen, "Solar Energy Fundamentals and Modeling Techniques: Atmosphere, Environment, Climate Change and Renewable Energy", 1st Edition, Springer-Verlag London,2008.
4. Weidong Xiao, "Photovoltaic Power System: Modeling, Design, and Control", 1st Edition, Wiley, 2017.

21PEE39	ENERGY STORAGE SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To outline the need for energy storage systems
- To explain the structure of thermal storage systems
- To summarize the various concepts of chemical storage system
- To classify the various electromagnetic storage system
- To interpret the working of electrochemical storage system

UNIT I	ENERGY STORAGE SYSTEMS OVERVIEW	9

Scope of energy storage, needs and opportunities in energy storage, Technology overview and key disciplines, comparison of time scale of storages and applications, Energy storage in the power and transportation sectors. Importance of energy storage systems in electric vehicles, Current electric vehicle market.

UNIT II	THERMAL STORAGE SYSTEM	9

Heat pumps, hot water storage tank, solar thermal collector, application of phase change materials for heat storage-organic and inorganic materials, efficiencies, and economic evaluation of thermal energy storage systems.

UNIT III	CHEMICAL STORAGE SYSTEM	9

Hydrogen, methane , concept of chemical storage of solar energy, application of chemical energy storage system, advantages and limitations of chemical energy storage, challenges, and future prospects of chemical storage systems.

UNIT IV	ELECTROMAGNETIC STORAGE SYSTEMS	9

Double layer capacitors with electrostatically charge storage, superconducting magnetic energy storage (SMES), concepts, advantages and limitations of electromagnetic energy storage systems, and future prospects of electrochemical storage systems.

UNIT V	ELECTROCHEMICAL STORAGE SYSTEM	9

Batteries-Working principle of battery, primary and secondary (flow) batteries, battery performance evaluation methods, major battery chemistries and their voltages- Li-ion battery&Metal hydride battery vs lead-acid battery. Supercapacitors: Working principle of

supercapacitor, types of supercapacitors, cycling and performance characteristics, difference between battery and supercapacitors, Introduction to Hybrid electrochemical super capacitors. Fuel cell: Operational principle of a fuel cell, types of fuel cells, hybrid fuel cell-battery systems and hybrid fuel cell-supercapacitor systems.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Explain the opportunities for energy storage systems
CO2: Interpret the efficiency of thermal storage systems
CO3: Outline the various applications of chemical storage system
CO4: Summarize the merits and demerits of electromagnetic storage system
CO5: Classify the various electrochemical storage system

TEXT BOOKS:

1. Dr. SatyenderSingh, "Energy Storage Systems: An Introduction" Nova Publisher,1st Edition, 2020.
2. Luisa Cabeza, "Advances in Thermal Energy Storage Systems-Methods and Applications",2nd Edition, Woodhead Publishing Series in Energy, 2020.
3. Klaus Brun , Timothy C. Allison, "Thermal, Mechanical, and Hybrid Chemical Energy Storage Systems", 1st Edition,Academic Press Inc,November 2020.
4. Slobodan Petrovic , "Battery Technology Crash Course: A Concise Introduction",1st Edition, Springer, 2021.

REFERENCES

1. Slobodan Petrovic, "Electrochemistry Crash Course for Engineers "1st Edition, Springer, 2021
2. V. K. Mathew, Tapano Kumar Hotta, Hafiz Muhammad Ali, SenthilarasuSundaram, "Energy Storage Systems: Optimization and Applications", 1st Edition,Springer,2022.
3. Igor V. Barsukov, Christopher S. Johnson , "New Carbon Based Materials for Electrochemical Energy Storage Systems",1st Edition, NATO Science Series,2006.
4. B. K. Middleton, M. M. Aziz, "Magnetic Storage Systems Beyond 2000", 1st Edition, Springer Netherlands,2001.

21PEE40	INDUSTRIAL INSTRUMENTATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To explain different methods used for measuring force, torque and speed
- To classify the vibration, acceleration and density measurement instruments
- To summarize the types of viscosity and humidity measurement system
- To outline the temperature sensor selection criteria
- To show techniques used for pressure and vacuum measurement

UNIT I	MEASUREMENT OF FORCE, TORQUE AND SPEED	9

Different types of load cells: Hydraulic, Pneumatic, Strain gauge, Magneto-elastic and Piezoelectric load cells – Different methods of torque measurement: Strain gauge, Relative angular twist. Sped measurement: Capacitivetacho, Drag cup type tacho, D.C and A.C tacho generators – Stroboscope.

UNIT II	MEASUREMENT OF ACCELERATION, VIBRATION AND	9

	DENSITY	
Accelerometers: LVDT, Piezoelectric, Strain gauge and Variable reluctance type accelerometers – Mechanical type vibration instruments – Seismic instruments as accelerometer – Vibration sensor – Calibration of vibration pickups – Units of density and specific gravity – Baume scale and API scale – Densitometers: Pressure type densitometers, Float type densitometers, Ultrasonic densitometer and gas densitometer.		
UNIT III	**MEASUREMENT OF VISCOSITY, HUMIDITY AND MOISTURE**	**9**
Viscosity: Saybolt viscometer – Rotameter type and Torque type viscometers – Consistency Meters – Humidity: Dry and wet bulb psychrometers – Resistive and capacitive type hygrometers – Commercial type dew meter. Moisture: Different methods of moisture measurements –Thermal, Conductivity and Capacitive sensors, Microwave, IR and NMR sensors, Application of moisture measurement – Moisture measurement in solids.		
UNIT IV	**TEMPERATURE MEASUREMENT**	**9**
Definitions and standards – Primary and secondary fixed points – Different types of filed in system thermometers – Sources of errors in filed in systems and their compensation – Bimetallic thermometers – IC sensors – Thermocouples: Laws of thermocouple, Fabrication of industrial thermocouples, Reference junctions compensation, Signal conditioning for thermocouple, Commercial circuits for cold junction compensation.		
UNIT V	**PRESSURE MEASUREMENT**	**9**
Units of pressure – Manometers: Different types, Elastic type pressure gauges: Bourdon tube, Bellows, Diaphragms and Capsules – Electrical methods: Elastic elements with LVDT and strain gauges – Capacitive type pressure gauge – Piezo resistive pressure sensor-Resonator pressure sensor – Pressure gauge selection, installation and calibration using dead weight ester.		
		TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Show the various methods used for measurement of force, torque and speed
CO2: Summarize the operating principle of vibration, acceleration and density measurement
CO3: Outline working of viscosity, moisture and humidity measurement instrument
CO4: Classify the devices used for temperature sensing
CO5: Explain the various methods used for pressure and vacuum measurement

TEXT BOOKS:

1. Doebelin, E.O. and Manik, D.N., "Measurement systems Application and Design", 6th Edition, McGraw-Hill Education Pvt. Ltd, 2011.
2. Jones, B.E., "Instrument Technology", Vol.2, International Edition,1stEdition, Butterworth-Heinemann, 2003
3. Liptak, B.G., "Instrumentation Engineers Handbook (Measurement)", 1st Edition, CRC Press, 2005.
4. Patranabis, D., "Principles of Industrial Instrumentation", 3rd Edition, McGraw-Hill Education, 2017.

REFERENCES

1. Eckman D.P., "Industrial Instrumentation", 1stEdition, Wiley Eastern Limited**,** 1990.
2. Singh,S.K., "Industrial Instrumentation and Control", 1st Edition, Tata Mc-Graw-Hill Education Pvt. Ltd., New Delhi,2009.

3. A.K. Sawhney, "A Course in Electronic Measurements and Instrumentation", 1st Edition, DhanpatRai& Co. (P) Limited, 2015.
4. Jain, R.K., Mechanical and Industrial Measurements, 1st Edition, Khanna Publishers, Delhi, 1999.

21PEE41	INDUSTRIAL ELECTRICAL AND ELECTRONICS ENGINEERING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To outline the performance of manufacturing engineering systems
- To illustrate the basic subsystems and sequence of SPM and GPM machines
- To explain the architecture of Industrial machine controllers
- To interpret efficient industrial design for all modern requirements
- To summarize PLC module configuring

UNIT I	MANUFACTURING ENGINEERING SYSTEM	9

Batch, Cell concept, Individual part flow, Takt time, Process Time, Lead time, Cycle time, Overall Equipment Effectiveness (OEE), Process Flow diagram, Lean manufacturing technique and Six sigma overview

UNIT II	SUBSYSTEMSOF SPECIAL PURPOSE MACHINE (SPM)/GENERAL PURPOSE MACHINE (GPM)	9

Basic Subsystems of a machine - Base & Columns, Fixture, Tooling's, Spindle, Slide ways, Hydraulics, Pneumatics, Lubrication, Cladding & Auto door, Coolant & Chip tray.Electrical - Control Cabinet, Servo drives, Operator console, Human machine interface (HMI)/Man Machine Interface (MMI).

UNIT III	OPERATING MODES OF SPM/GPM	9

Auto cycle sequence - Auto Door movement, component clamp/de-clamp, Slide feed, Axes interpolation in a computer numerical control(CNC) machine, Automatic Tool Change, Metal cutting at regulated rpm, Cutting coolant and bed coolant. Safety interlocks- Levels of safety, redundancy levels and poka yoke used in machining process & power saving techniques.

UNIT IV	ARCHITECTURE OF MACHINE CONTROLLERS	9

Sensors & transducers, Actuators, Relays, contactor, power supply, fuse, Isolator, Miniature Circuit Breaker. MCCB – Molded Case Circuit Breaker. ELCB – Earth Leakage Circuit Breaker, Controlling Induction motor from VFD, Servomotor& Servo drives, Encoders, Operator panel elements (Push button, Selector switch, lamp, HMI etc), PLC & CNC controllers. I/O assignment - Addressing Digital I/O, Analogue I/O & counter inputs for a machine based on application. Selection of elements for application control - PLC/CNC controller, HMI/MMI, sensors, transducers, actuators, motors, drives, Circuit breakers, power supply, relays, cables, Earthing/shielding of measuring equipment

UNIT V	PROGRAMMABLE LOGIC CONTROLLER / COMPUTERIZED NUMERICAL CONTROL	9

Configuring PLC modules using ladder, Bit, Byte & words, addressing digital I/O signals, Concept of NO/NC elements, coils, flags, Boolean operation, AND/OR/NOT, Pulse triggered execution, serial, parallel and latch execution sequence, Relays, Counter, Timers, Registers, Mathematical and logical instructions, building tags. Addressing analogue I/Os in Ladder,

Programming an analogue I/O block, Read/Write functions, Programming an encoder using counter block, Compare functions Examples of very commonly used safety logics/techniques, building poka yoke in ladder using peripheral sensors, power saving techniques.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Summarize the process flow diagram, Lean manufacturing technique and Six sigma.
CO2: Interpret the various subsystems of SPM and GPM machines.
CO3: Outline the need for control of safety devices in industrial machine controllers.
CO4: Explain the selection of elements for application control.
CO5: Illustrate the process of controlling machine using PLC.

TEXT BOOKS:

1. Black, J. T., Hunter, Steve L., "Lean Manufacturing Systems and Cell Design", 1st Edition, Society of Manufacturing Engineers (SME), 2003.
2. Frank Voehl, H. James Harrington, Chuck Mignosa, Rich Charron, "The Lean Six Sigma Black Belt Handbook: Tools and Methods for Process Acceleration", 1st Edition, Productivity Press, 2013.
3. W. Bolton, "Programmable Logic Controllers", 1st Edition, Newnes imprint of Elsevier, 2006.
4. Frank D.Petruzella, "Programmable Logic Controllers", 4thEdition McGraw-Hill, 2011.

REFERENCES

1. Alan Overby, "CNC Machining Handbook: Building, Programming, and Implementation",1st Edition, McGraw-Hill TAB Electronics, 2010.
2. Edward Ford, "Getting Started with CNC: Personal Digital Fabrication with Shapeoko and Other Computer-Controlled Routers",1st Edition, Maker Media, Inc, 2016.
3. Suk-Hwan Suh, Seong Kyoon Kang, Dae-Hyuk Chung, Ian Stroud, "Theory and Design of CNC Systems",1st Edition, Springer-Verlag London,2008.
4. Kandray, Daniel E., "Programmable Automation Technologies - An Introduction to CNC, Robotics and PLCs", 1st Edition, Industrial Press,2010.

21PEE42	ANALYTICAL INSTRUMENTATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To explain the construction of spectrometry
- To classify chromatography and its applications
- To summarize the instruments used as gas analyzer and pollution detector
- To interpret the method for pH and conductivity measurement
- To outline the types of mass spectrometry.

UNIT I SPECTROPHOTOMETRY **9**

Spectral methods of analysis – Beer-Lambert law – UV-Visible spectroscopy – IR Spectrophotometry - FTIR spectrophotometry – Atomic absorption spectrophotometry - Flame emission and atomic emission photometry – Construction, working principle, sources detectors and applications.

UNIT II CHROMATOGRAPHY **9**

General principles – classification – chromatographic behavior of solutes – quantitative

determination – Gas chromatography – Liquid chromatography – High-pressure liquid chromatography – Applications.		
UNIT III	**INDUSTRIAL GAS ANALYZERS AND POLLUTION MONITORING INSTRUMENTS**	**9**
Gas analyzers – Oxygen, NO2 and H2S types, IR analyzers, thermal conductivity detectors, analysis based on ionization of gases. Air pollution due to carbon monoxide, hydrocarbons, nitrogen oxides, sulphur dioxide estimation - Dust and smoke measurements		
UNIT IV	**pH METERS AND DISSOLVED COMPONENT ANALYZERS**	**9**
pH meter – working principle- components-selective ion electrodes - Principle of pH and conductivity measurements - dissolved oxygen analyzer – Sodium analyzer – Silicon analyzer – Water quality Analyzer.		
UNIT V	**NUCLEAR MAGNETIC RESONANCE AND MASS SPECTROMETRY**	**9**
NMR – Basic principles – Continuous and Pulsed Fourier Transform NMR spectrometer – Mass Spectrometry – Sample system – Ionization methods – Mass analyzers – Types of mass spectrometry.		
		TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Outline the various spectral method of analysis
CO2: Summarize the working of chromatography
CO3: Interpret the dust and smoke detection using gas analyzer
CO4: Classify different methods for pH and conductivity measurement
CO5: Explain the basic principle of mass spectrometry.

TEXT BOOKS:

1. Willard, H.H., Merritt, L.L., Dean, J.A., Settle, F.A., "Instrumental Methods of Analysis", 7th Edition, CBS publishing & distribution, 2012.
2. Braun, R.D., "Introduction to Instrumental Analysis", 1st Edition,Pharma Book Syndicate,2006.
3. Robert E. Sherman., "Analytical Instrumentation", 1st Edition, Instruments Society of America, 1996.
4. A.K. Sawhney, "A Course in Electronic Measurements and Instrumentation", 1st edition,DhanpatRai& Co. (P) Limited, 2015.

REFERENCES

1. Khandpur, R.S., "Handbook of Analytical Instruments", 2nd Edition, Tata McGraw-Hill publishing Co. Ltd., 2007.
2. Ewing, G.W., "Instrumental Methods of Chemical Analysis", 5th Edition, McGraw-Hill, reprint 1985. (Digitized in 2007).
3. Liptak, B.G., "Process Measurement and Analysis", CRC Press, 5th Edition, 2015.
4. Doebelin, E.O. and Manik, D.N., "Measurement systems Application and Design", 6th Edition, McGraw-Hill Education Pvt. Ltd, 2011.

21PEE43	SOFT COMPUTING TECHNIQUES AND APPLICATIONS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To show the architecture of biological and artificial neuron model
- To explain the role of neural networks for control
- To outline the process of fuzzification and defuzzification system
- To summarize the various applications of fuzzy logic systems
- To interpret the steps in genetic algorithm

UNIT I	ARCHITECTURES –ARTIFICIAL NEURAL NETWORKS	9

Introduction – Biological neuron – Artificial neuron – Neuron model – Supervised and unsupervised learning- Single layer – Multi layer feed forward network – Learning algorithm- Back propagation network.

UNIT II	NEURAL NETWORKS FOR CONTROL	9

Feedback networks – Discrete time Hopfield networks – Transient response of continuous time system – Applications of artificial neural network - Process identification – Neuro controller for inverted pendulum.

UNIT III	FUZZY SYSTEMS	9

Classical sets – Fuzzy sets – Fuzzy relations – Fuzzification – Defuzzification – Fuzzy rules - Membership function – Knowledge base – Decision-making logic – Introduction to neuro fuzzy system- Adaptive fuzzy system

UNIT IV	APPLICATION OF FUZZY LOGIC SYSTEMS	9

Fuzzy logic control: Home heating system - liquid level control - aircraft landing- inverted pendulum -fuzzy PID control, Fuzzy based motor control.

UNIT V	GENETIC ALGORITHMS	9

Basic concept of Genetic algorithm and detail algorithmic steps-adjustment of free Parameters- Solution of typical control problems using genetic algorithm- Concept on some other search techniques like tabu search and ant colony search techniques for solving optimization problems

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Interpret the difference between supervised and unsupervised learning network.
CO2: Outline the applications of artificial neural network
CO3: Explain fuzzy rule and membership functions
CO4: Summarize the fuzzy logic control made in various applications
CO5: Show the various applications of genetic algorithm

TEXT BOOKS:

1. LauranceFausett, Englewood Cliffs, N.J., "Fundamentals of Neural Networks", 1st Edition,Pearson Education, 1992.
2. Timothy J. Ross, "Fuzzy Logic with Engineering Applications", 3rdEdition, Tata McGraw Hill, 2010.
3. S.N.Sivanandam and S.N.Deepa, "Principles of soft computing", 2ndEdition, Wiley India Edition, 2013.
4. M.Gen and R,Cheng, "Genetic algorithms and optimization", 1st Edition, Wiley Series in Engineering Design and Automation, 2000.

REFERENCES

1. N.P.Padhy and S.P.Simon, "Soft computing with MATLAB programming", 1st Edition, Oxford publishers, 2015.
2. John Yen & Reza Langari, "Fuzzy Logic – Intelligence Control & Information", 1st Edition,Pearson Education, 2003.
3. Hagan, Demuth, Beale, "Neural Network Design", 1stEdition, Cengage Learning, 2012.
4. William S.Levine, "Control System Advanced Methods," 2nd Edition, The Control Handbook CRC Press, 2010.

21PEE44	DESIGN OF ELECTRICAL INSTALLATIONS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To interpret the purpose of cost estimation in electrical installation
- To classify wiring system for domestic and industrial applications
- To explain the procedure for electrical layout in domestic application
- To outline the steps involved in preparing electrical layout for industrial application
- To show the procedure for electrical motor installation

UNIT I	INTRODUCTION	9

Purpose of estimating and costing, proforma for making estimates, preparation of materials schedule, costing, price list, tender document, net price list, market survey, overhead charges, labor charges, electrical point method and fixed percentage method, contingency, profit, purchase system, enquiries, comparative statements, orders for supply, payment of bills. Tenders – its constituents, finalization, specimen tender.

UNIT II	TYPES OF WIRING	9

Cleat, batten, casing capping and conduit wiring, comparison of different wiring systems, selection and design of wiring schemes for particular situation (domestic and Industrial).Selection of wires and cables, wiring accessories and use of protective devices i.e. MCB, ELCB etc. Use of wire-gauge and tables (to be prepared/arranged)

UNIT III	ESTIMATING AND COSTING DOMESTIC INSTALLATIONS	9

Standard practice as per IS and IE rules. Planning of circuits, sub-circuits and position of different accessories, electrical layout, preparing estimates including cost as per schedule rate pattern and actual market rate

UNIT IV	ESTIMATING AND COSTING INDUSTRIAL INSTALLATIONS	9

Relevant IE rules and IS standard practices, planning, designing and estimation of installation for single phase motors of different ratings, electrical circuit diagram, starters, preparation of list of materials, estimating and costing exercises on workshop with single phase, 3-phase motor load and the light load (3-phase supply system), Service line connections estimate for domestic and Industrial loads (over-head and Under- ground connections) from pole to energy meter.

UNIT V	INSTALLATION PLAN	9

Installation plan, single line diagram and prepare the estimate of cost and list of material for the following 2HP 3-phase Induction Motor for screw milling machine,3HP 3-phase Induction Motor for small lathe,5HP 3-phase Induction Motor for milling machine, One 1HP 3-phase Induction Motor for grinder Installation plan, single line diagram and prepare the estimate of cost and list of

material for the following machinery.5, 3, 1, 1/2 HP 3-Phase 400v Induction Motor.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Show the various types of estimation methods in electrical installation.
CO2: Outline the selection process of wires and cables.
CO3: Explain the estimate preparation of domestic installations.
CO4: Classify the IE rules and IS standard in industrial installations.
CO5: Interpret the procedure for electrical motor installation.

TEXT BOOKS:

1. B Gupta, "A Course in Electrical Installation, Estimating and Costing",2nd Edition, S.K. Kataria& Sons, 2013.
2. Raina,Battacharya, "Electrical Design: Estimation & Costing", 2nd Edition,Wiley Eastern,2009.
3. S.K Bhattacharya," Estimating and Costing",3rd Edition, Tata McGraw Hill,2006.
4. V.K. Jain,Amitabh Bajaj , "Design of Electrical Installations",1st Edition, Laxmi Publications, 2016.

REFERENCES

1. Surjeet Singh, "Estimating and Costing", 2nd Edition, DhanpatRai& Co., 2003.
2. S.L Uppal, "Estimating and Costing", 2nd Edition, Khanna Publishers, 2004.
3. N Alagappan and B Ekambaram, "Electrical Estimating and Costing",2nd Edition, TMH, 2006.
4. ISI, National Electric Code, Bureau of Indian Standard Publications, 2011.

21PEE45	HIGH VOLTAGE ENGINEERING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To summarize the various types of over voltages in power system and protection methods.
- To infer the different methods for the generation of over voltages and currents.
- To outline the various methods to measure high voltages and currents
- To explain the nature of breakdown mechanism in solid, liquid and gaseous dielectrics.
- To illustrate the testing procedure in power apparatus and high voltage applications insulation coordination.

UNIT I	OVER VOLTAGES IN ELECTRICAL POWER SYSTEMS	9

Causes of over voltages and its effects on power system – Lightning, switching surges and temporary over voltages, Corona and its effects – Reflection and Refraction of Travelling waves- Protection against over voltages- Insulation Coordination

UNIT II	GENERATION OF HIGH VOLTAGES AND HIGH CURRENTS	9

Generation of high D.C. Voltages: Half and full wave rectifier circuits; Voltage doubler circuits; Voltage multiplier circuits; Electrostatic machines- Generation of high A.C. Voltages of power frequency- Generation of high A.C. Voltages : Cascade transformers - High frequency transformer - Generation of impulse and switching voltages - Generation of impulse currents- - Triggering and control of impulse generators.

UNIT III	MEASUREMENT OF HIGH VOLTAGES AND HIGH CURRENTS	9

High Resistance with series ammeter – Dividers, Resistance, Capacitance and Mixed dividers –

Peak Voltmeter, Generating Voltmeters - Capacitance Voltage Transformers, Electrostatic Voltmeters – Sphere Gaps - High current shunts- Digital techniques in high voltage measurement.

UNIT IV	DIELECTRIC BREAKDOWN	9

Gaseous breakdown in uniform and non-uniform fields – Corona discharges – Vacuum breakdown –Conduction and breakdown in pure and commercial liquids, Breakdown mechanisms in solid and composite dielectrics.

UNIT V	HIGH VOLTAGE TESTING AND APPLICATION	9

Need for testing -High voltage testing of electrical power apparatus as per International and Indian standards – Power frequency, impulse voltage and DC testing of Insulators, circuit breakers, bushing, isolators and transformers- - Application of high voltage engineering in food processing and green energy corridor –safety and electrical hazard.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Outline the causes of over voltages in power system and travelling waves due to lightning
CO2: Demonstrate various methods to produce high DC, AC and impulse voltages and currents.
CO3: Summarize various methods to measure high voltage DC, AC and impulse voltages and currents
CO4: Explain breakdown phenomena in various dielectrics like gas, liquid, solid and composite materials.
CO5: Illustrate the High voltage testing of electrical power apparatus as per International and Indian standards and applications of high voltage engineering

TEXT BOOKS:

1. S.Naidu and V. Kamaraju, "High Voltage Engineering", Tata McGraw Hill, Fifth Edition, 2013.
2. E. Kuffel and W.S. Zaengl, J.Kuffel, "High voltage Engineering fundamentals", Newnes Second Edition Elsevier , New Delhi, 2005.
3. Allan Greenwood, 'Electrical Transients in Power Systems', 2nd Edition, Wiley Inter Science, New York, 1991.
4. Subir Ray,' An Introduction to High Voltage Engineering' PHI Learning Private Limited, NewDelhi, Second Edition, 2013.

REFERENCES:

1. L.L. Alston, "High Voltage Technology", Oxford University Press, First Indian Edition, 2011.
2. C.L. Wadhwa, "High Voltage Engineering", New Age International Publishers, Third Edition, 2010.
3. R.D. Begamudre, "Extra High Voltage AC Transmission Engineering", 3rd Edition, Wiley Eastern Limited, 1986.
4. Y.Hase, "Handbook of Power System Engineering", 2nd Edition, Wiley India, 2012.

ONE CREDIT COURSES

21OCEE01	SOFTWARES FOR ELECTRICAL ENGINEERS	L	T	P	C
		0	0	2	1

COURSE OBJECTIVES:

- To Apply numerical methods for engineering problems
- To Make use of MATLAB to solve computational problems

LIST OF EXPERIMENTS

1. Study of Introduction to MATLAB.
2. Study of basic matrix operations.
3. Simulation of DC Circuits.
4. Determination of time response of an R-L-C circuit.
5. Study of Three Phase Inverter With 180^0 Conduction Mode By Using Matlab Programming.
6. Performance Evaluation of short Transmission Line.
7. Performance operation on signals and sequences.

TOTAL: 15 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Make use of MATLAB for Electrical Engineering.

CO2: Construct plots and export this for use in reports and presentations.

TEXT BOOKS:

1. Stephen J. Chapman- Thomson, "MATLAB Programming for Engineers Book", 1st Edition, Ware companion series, 2004
2. Stormy Attaway, "A Practical Introduction to Programming and Problem Solving", 3rd Edition, Butterworth-Heinemann, 2013

REFERENCES

1. Mathew & Fink "Numerical Methods Using MATLAB", 1st Edition, Pearson, 1998.
2. Rudra Pratap "Getting started with Matlab: A quick introduction for scientist & engineers", 1st Edition, Oxford, 2010.

21OCEE02	ANN APPLICATIONS TO ELECTRICAL ENGINEERING	L	T	P	C
		0	0	2	1

COURSE OBJECTIVES:

- To illustrate applications of artificial neural networks for real time operations
- To Explain the Neural Networks and its application in electrical Engineering

LIST OF EXPERIMENTS

1. Estimate the power system restoration using Artificial Neural Network
2. Conduct a test for the pattern classification for floral identification using ANN
3. Estimate the PID parameters for controller using ANN
4. Conduct Neuro-Fuzzy Wavelet based Adaptive MPPT Algorithm for Photovoltaic Systems

Using MATLAB.

5. Evaluate maintenance scheduling for a power system using ANN
6. Conduct economic load dispatch for a given power system using ANN
7. Perform a load flow analysis using ANN

TOTAL: 15 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Outline the concept of biological neuron and types of neural network

CO2: Summarize the applications of neural networks in electrical engineering

TEXTBOOKS:

1. Laurene V. Fausett, "Fundamentals of Neural Networks: Architectures, Algorithms, and Applications", 1st Edition, Pearson Education, 1993.
2. W. T. Miller, R. S. Sutton, P. J. Webros, "Neural Networks for Control", 1st Edition, MIT Press, 1996.

REFERENCES :

1. B. Yegnanarayana, "Artificial Neural Networks", 12th Edition, Prentice Hall of India Pvt. Ltd, New Delhi, 2006.
2. S.Rajasekaran, G. A. Vijayalakshami, "Neural Networks, Fuzzy Logic and Genetic Algorithms: Synthesis & Applications", 2nd Edition, PHI Learning2017

21OCEE03	SOLAR POWER ENGINEERING	L	T	P	C
		0	0	2	1

COURSE OBJECTIVES:

- To explain the basic concepts in solar PV Energy System.
- To demonstrate the performance assessment of grid connected and standalone solar Power System

LIST OF EXPERIMENTS

1. Simulation study on Solar PV Energy System.
2. Study the performance characteristics of solar PV system.
3. Study the P-V and V-I characteristics of single PV module.
4. Study the P-V and V-I characteristics of PV module during shadowing.
5. Study performance assessment of standalone solar PV system.
6. Simulation study on Solar PV Energy System (1kW) for Off-Grid Inverter
7. Simulation study on Solar PV Energy System (1kW) for On-Grid Inverter.

TOTAL: 15 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Apply the controllers for hybrid systems.

CO2: Experiment with the characteristics of solar PV system.

TEXT BOOKS:

1.Chetan Singh Solanki., Solar Photovoltaic: "Fundamentals, Technologies and Application", 1st Edition, PHI Learning Pvt., Ltd., 2009.

2. Jha .A.R, "Solar Cell Technology and Applications", 1st Edition, CRC Press, 2010.

REFERENCES

1. Partain .L.D, Fraas L.M., "Solar Cells and Their Applications", 2nd Edition, Wiley, 2010.

2. Sukhatme .S.P, Nayak .J.K, "Solar Energy", 1st Edition, Tata McGraw Hill Education Private Limited, New Delhi, 2010.

21OCEE04	TESTING AND CALIBRATION SYSTEM	L	T	P	C
		0	0	2	1

COURSE OBJECTIVES:

- To explain the basic concepts and terminologies of testing systems
- To demonstrate the performance of various measuring instruments at different loading conditions

LIST OF EXPERIMENTS

1. Analyze a comparative experimental study on calibration of a Pressure gauge using a dead weight pressure gauge calibrator and the digital pressure calibrator.
2. Evaluate the estimation of uncertainties during flow measurement using rotameter.
3. Validate the calibrator calculations of the voltmeter and ammeter for a given electrical circuit.
4. Conduct a test for the verification and validation of a three phase wattmeter and a single phase wattmeter.
5. Conduct a test for measuring humidity using a hygrometer.
6. Perform the experiment on RTD and thermocouple for probe calibration.
7. Conduct an experiment on torque transducer calibration and check the error.

TOTAL: 15 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Analyze and estimate the errors present in measuring system

CO2: Interpret the measured data with calculated values

REFERENCES :

1. Alessandro Brunelli ,"Calibration Handbook of Measuring Instruments", 1st Edition,ISA,2014
2. Halit Eren, " Electronic Portable Instruments-Design and Applications", 1st Edition, CRC Press, 2004

TEXTBOOKS:

1. Ramon Pallas-Areny/John.G.Webster "Sensors and Signal Conditioning", 2nd Edition, Wiley India, 2011.
2. Paul.D.Q, "An Introduction to Measuration and Calibration", 1st Edition, Campbell Industrial Press, 2019.

21OCEE05	HYBRID ENERGY SYSTEMS	L	T	P	C
		0	0	2	1

COURSE OBJECTIVES:

- To explain the basic concepts and terminologies of hybrid power systems.
- To interpret the intelligent controllers for hybrid systems.

LIST OF EXPERIMENTS

1. Study performance assessment of standalone solar PV system.
2. Study the performance characteristics of wind power plant.
3. Performance analysis of Hybrid (Solar and Wind) power plant.
4. Experiment on Performance assessment of micro Wind Energy Generator.
5. Simulation on Hybrid Power.
6. Experiments on Performance Assessment of Fuel Cell.
7. Simulation on Intelligent Controllers for Hybrid Systems.

TOTAL: 15 PERIODS

COURSE OUTCOMES: At the end of the course, learners will be able to:

CO1: Analyze Performance assessment of hybrid systems

CO2: Demonstrate the intelligent controllers for hybrid systems.

REFERENCES :

1. D.P.Kothari, K.C Singal, Rakesh Ranjan "Renewable Energy Sources and Emerging Technologies", 2nd Edition, PHI Learning Pvt. Ltd, New Delhi, 2013.
2. Scott Grinnell, "Renewable Energy & Sustainable Design", 1st Edition, CENGAGE Learning, USA, 2016.

TEXTBOOKS:

1. Richard A. Dunlap," Sustainable Energy" 1st Edition, Cengage Learning India Private Limited, Delhi, 2015.
2. A.Shunmugalatha, M.Devaki and R.Saranya, Renewable Energy Systems, 1st Edition, Technical publication, 2020.

21OCEE06	DESIGN THINKING	L	T	P	C
		1	0	0	1

COURSE OBJECTIVES:

- To explain the concept of design thinking for product and service development.
- To summarize the fundamental concept of innovation and design thinking.

Unit-I	PROCESS OF DESIGN	7

Understanding Design thinking - Shared model in team-based design – Theory and practice in Design thinking – Explore presentation signers across globe – MVP or Prototyping

Unit-II	TOOLS FOR DESIGN THINKING	8

Real-Time design interaction capture and analysis – Enabling efficient collaboration in digital space – Empathy for design – Collaboration in distributed Design.

	TOTAL : 15 PERIODS

COURSE OUTCOMES:

At the end of the course, learners will be able to:

CO1: Interpret the various design process procedure.

CO2: Outline the design ideas through different technique.

TEXT BOOKS:

1. John.R.Karsnitz, Stephen O'Brien and John P. Hutchinson, "Engineering Design", 2nd edition, Cengage learning (International edition), 2013.

2. Roger Martin, "The Design of Business: Why Design Thinking is the Next Competitive Advantage", 2nd edition, Harvard Business Press, 2009.

REFERENCE BOOKS:

1. Yousef Haik and Tamer M.Shahin, "Engineering Design Process", 2nd edition, Cengage Learning, 2011.

2. Jeanne Liedtka, Andrew King and Kevin Bennett, "Solving Problems with Design Thinking - Ten Stories of What Works" 2nd edition, Columbia Business School Publisher, 2013.