RAJALAKSHMI ENGINEERING COLLEGE
(AN AUTONOMOUS INSTITUTION AFFILIATED TO ANNA UNIVERSITY)
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

DEPARTMENT VISION AND MISSION

VISION

To be an international centre in education, research and the application of knowledge, to benefit the society globally in the field of Electrical and Electronics Engineering

MISSION

- To impart high quality technical education and develop Electrical and Electronics Engineers with a sound theoretical combined with practical skills in all the areas concerning the discipline.
- To inculcate innovative research capabilities and exemplary professional conduct to lead and to use technology for the progress of our country.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

[1] To provide students with a strong foundation in mathematics, science and engineering, necessary to understand and solve engineering problems. Prepare the students for a successful career in industries and also for higher studies.

[2] To enable the students to acquire the ability to analyze, design and build electrical and electronic systems, needed in power electronic drives, variety of controllers, and power systems.

[3] To impart students with a sound knowledge of software tools and skills for taking up research in upcoming areas in the field of electrical and electronics engineering, and for embarking on entrepreneurial ventures with an aptitude for lifelong learning.

[4] To impart communication skills, to inculcate values and professional ethics, leadership qualities and team spirit for an overall personality development, to create environmental awareness and a passion for using the knowledge acquired, for addressing the societal concerns.

(A) PROGRAM OUTCOMES (POs)

Engineering Graduates will be able to:

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

(B) PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO 1. Analyse, model and design Electrical and Electronic circuits and machines**.**

PSO 2. Comprehend the structure of power apparatus and systems and analyze their operation, control, protection and utilization**.**

PSO 3. Use of programmable devices, embedded systems and software 33 for the simulation, design and building newer electrical and electronic systems leading to research and invention.

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
B.E. ELECTRICAL AND ELECTRONICS ENGINEERING
REGULATION – 2023
CHOICE BASED CREDIT SYSTEM
CURRICULUM AND SYLLABUS [I SEM –IV SEM]

SEMESTER I

S.NO	COURSE CODE	COURSE TITLE	PERIODS / WEEK					CATEGORY
			L	T	P	TOTAL	CREDITS	
1	HS 23111	Technical Communication I	2	0	0	2	2	HS
2	MA23111	Linear Algebra and Calculus	3	1	0	4	4	BS
3	CY23131	Chemistry for Electronics Engineering	3	0	2	5	4	BS
4	GE23131	Programming using C	1	0	6	7	4	ES
5	GE23111	Engineering Graphics	2	0	4	6	4	ES
6	GE23122	Engineering Practices - Electrical and Electronics	0	0	2	2	1	ES
7	MC23111	Indian Constitution and Freedom Movement	3	0	0	3	0	MC
8	GE23117	தமிழர்மரபு /Heritage of Tamils	1	0	0	1	1	HS
	TOTAL		**15**	**1**	**14**	**30**	**20**	

SEMESTER II

S.NO	COURSE CODE	COURSE TITLE	PERIODS / WEEK					CATEGORY
			L	T	P	TOTAL	CREDITS	
1	HS23221/ HS 23222	Technical Communication II/ English for Professional Competence	0	0	2	2	1	HS
2	MA23212	Differential Equation and Complex Variables	3	1	0	4	4	BS
3	PH23232	Physics for Electronics Engineering	3	0	2	5	4	BS
4	CS23231	Data Structures	3	0	4	7	5	ES
5	EE23212	Electric Circuits	3	0	0	3	3	PC
6	EE23221	Electric Circuits Laboratory	0	0	2	2	1	PC
7	GE23121	Engineering Practices - Civil and Mechanical	0	0	2	2	1	ES
8	MC23112	Environmental Science and Engineering	3	0	0	3	0	MC
9	GE23217	தமிழரும் தொழில்நுட்பமும் / Tamils and Technology	1	0	0	1	1	HS
	TOTAL		**16**	**1**	**12**	**29**	**20**	

SEMESTER III

S.NO	COURSE CODE	COURSE TITLE	PERIODS / WEEK					CATEGORY
			L	T	P	TOTAL	CREDITS	
1	MA23312	Fourier Series and Number Theory	3	1	0	4	4	BS
2	EE23311	Electromagnetic Theory	3	0	0	3	3	ES
3	EE23312	Electrical Machines – I	3	0	0	3	3	PC
4	EE23313	Measurements and Instrumentation	3	0	0	3	3	PC
5	EE23314	Electronic Devices and Circuits	3	0	0	3	3	PC
6	EE23315	Power Plant Engineering	3	0	0	3	3	ES
7	EE23321	Electronic Devices and Circuits Laboratory	0	0	2	2	1	PC
8	CS23336	Introduction to Python Programming	1	0	4	5	3	ES
		TOTAL	**19**	**1**	**6**	**26**	**23**	

SEMESTER IV

S.NO	COURSE CODE	COURSE TITLE	PERIODS / WEEK					CATEGORY
			L	T	P	TOTAL	CREDITS	
1	EE23411	Electrical Machines – II	3	0	0	3	3	PC
2	EE23412	Transmission and Distribution	3	0	0	3	3	PC
3	EE23431	Digital Logic Circuits	3	0	2	5	4	PC
4	EE23432	Linear Integrated Circuits and Applications	3	0	2	5	4	PC
5	******	Open Elective – I	3	0	0	3	3	OE
6	EE23421	Electrical Machines Laboratory	0	0	4	4	2	PC
7	GE23421	Soft Skills-I	0	0	2	2	1	EEC
8	CS23422	Python Programming for Machine Learning	0	0	4	4	2	ES
		TOTAL	**15**	**0**	**14**	**29**	**22**	

SEMESTER V

S.NO	COURSE CODE	COURSE TITLE	PERIODS / WEEK					CATEGORY
			L	T	P	TOTAL	CREDITS	
1	EE23511	Power System Analysis	3	0	0	3	3	PC
2	EE23512	Power Electronics	3	0	0	3	3	PC
3	EE23513	Control Systems	3	0	0	3	3	PC
4	EE23P**	Professional Elective I	3	0	0	3	3	PE
5	EE23531	Microprocessors, Microcontrollers and Applications	3	0	2	5	4	PC
6	******	Open Elective – II	3	0	0	3	3	OE
7	EE23521	Control and Instrumentation Laboratory	0	0	2	2	1	PC
8	GE23627	Design Thinking and Innovation	0	0	4	4	2	EEC
9	GE23521	Soft Skills-II	0	0	2	2	1	EEC
		TOTAL	**18**	**0**	**10**	**28**	**23**	

SEMESTER VI

S.NO	COURSE CODE	COURSE TITLE	PERIODS / WEEK					CATEGORY
			L	T	P	TOTAL	CREDITS	
1	EE23611	Protection and Switchgear	3	0	0	3	3	PC
2	EE23612	Solid State Drives	3	0	0	3	3	PC
3	EE23613	Electric Energy Utilization and Conservation	3	0	0	3	3	PC
4	EE23631	Applications of IoT in Electrical Engineering	2	0	2	4	3	PC
5	EE23P**	Professional Elective II	3	0	0	3	3	PE
6	EE23P**	Professional Elective III	3	0	0	3	3	PE
7	EE23621	Power Electronics and Drives Laboratory	0	0	2	2	1	PC
8	EE23622	Applications of AI and ML in Electrical Engineering	0	0	4	4	2	EEC
9	GE23621	Problem Solving Techniques	0	0	2	2	1	EEC
		TOTAL	**17**	**0**	**10**	**27**	**22**	

SEMESTER VII

S.NO	COURSE CODE	COURSE TITLE	PERIODS / WEEK					CATEGORY
			L	T	P	TOTAL	CREDITS	
1	EE23711	Smart Grid	3	0	0	3	3	PC
2	EE23712	Power System Operation and Control	3	0	0	3	3	PC
3	EE23731	Renewable Energy Systems	3	0	2	5	4	PC
4	EE23P**	Professional Elective IV	3	0	0	3	3	PE
5	EE23721	Power System Simulation Laboratory	0	0	4	4	2	PC
6	EE23722	Project Work Phase I	0	0	8	8	4	EEC
7	EE23723	Internship	0	0	2	2	1	EEC
		TOTAL	**12**	**0**	**16**	**28**	**20**	

SEMESTER VIII

S.NO	COURSE CODE	COURSE TITLE	PERIODS / WEEK					CATEGORY
			L	T	P	TOTAL	CREDITS	
1	EE23P**	Professional Elective V	3	0	0	3	3	PE
2	EE23P**	Professional Elective VI	3	0	0	3	3	PE
3	EE23821	Project Work Phase IIS	0	0	12	12	6	EEC
		TOTAL	**6**	**0**	**12**	**18**	**12**	
								TOTAL CREDITS : 162

CREDIT DISTRIBUTION

CATEGORY	I	II	III	IV	V	VI	VII	VIII	Total
HS	3	2							5
BS	8	8	4						20
ES	9	6	9	2					26
EEC				1	3	3	5	6	18
PC		4	10	16	14	13	12		69
PE					3	6	3	6	18
OE				3	3				6
TOTAL	**20**	**20**	**23**	**22**	**23**	**22**	**20**	**12**	**162**

PROFESSIONAL ELECTIVES

Professional Elective	Vertical I Renewable Energy Technologies	Vertical II Electric Vehicle Technology	Vertical III Advanced Power Engineering	Vertical IV Advanced Power Electronic Systems	Vertical V Advanced Control System Engineering
1.	EE23A11 - Solar Energy Systems	EE23B21- Wiring Harness Design Engineering EE23B11- Electric Vehicle Architecture	EE23C11- HVDC Transmission	EE23D11- Analysis of Electrical Machines	EE23E11- Advanced Control Systems
2.	EE23A12 - Wind Energy Conversion Systems	EE23B31- Design of Electric Vehicle Charging System	EE23C12- Power Systems Transients	EE23D12- Power Electronics for Renewable Energy Systems	EE23E12- Digital Control Systems
3.	EE23A13 - Hybrid Energy Technology	EE23B32- Power Converters and Motors for Electric Vehicles	EE23C13- FACTS	EE23D13- Multilevel Power Converters	EE23E13- Fundamentals of Embedded Systems
4.	EE23A14 - Energy Storage Systems	EE23B33- Control of Electric Vehicles	EE23C14- Restructured Power systems	EE23D14- Modern Rectifiers and Resonant Converters	EE23E14- PLC and SCADA
5.	EE23A15 - Grid Integrating Techniques and Challenges	EE23B12- Electric Vehicles and Power Management	EE23C15- Power Quality	EE23D15- SMPS and UPS	EE23E15- Embedded Systems for Automobile Applications
6.	EE23A16 - Design, Modelling and Fabrication of	EE23B13- Grid Integration of Electric Vehicles	EE23C16- Power Systems Dynamics	EE23D31- Control of Power	EE23E16- Embedded

	Renewable Energy System Components			Electronic Circuits	Control for Electric Drives

SEMESTER - I

Course Code	Course Title	Category	L	T	P	C
HS23111	Technical Communication I	Theory	2	0	0	2

Common to all branches of I sem. B.E./ B.Tech. programmes

Objectives:

To facilitate students develop their comprehension skills

To enable students to improve their receptive skills

To equip learners with better vocabulary and enhance their writing skills

To aid students speak effectively in all kinds of communicative contexts.

To improve the learners' basic proficiency in workplace communication

UNIT-I **DEVELOPING COMPREHENSION SKILLS** 6

Listening: Introduction to Informational listening – Listening to Podcasts, News
Reading: Intentional Reading - Short Narratives and Passages.
Speaking: Introducing Oneself, Narrating a Story / Incident.
Writing: Sequential Writing – connecting ideas using transitional words (Jumbled Sentences), Process Description
Grammar: Verbs – Main & Auxiliary: Simple Tenses – Form, Function and Meaning.
Vocabulary: Word formation – Prefix, Suffix, Compound Words.

UNIT-II **LISTENING AND EXTENDED READING** 6

Listening: Deep Listening – Listening to Talk Shows and Debates
Reading: In-depth Reading - Scanning Passages
Speaking: Describing Current Issues, Happenings, etc..,
Writing: Note Making, Note Taking – Paragraph Writing
Grammar: Continuous Tenses, Prepositions, Articles
Vocabulary: One Word Substitutes, Phrasal Verbs.

UNIT-III **FORMAL WRITING AND VERBAL ABILITY** 6

Listening: Listening to Lectures and Taking Notes
Reading: Interpretation of Tables, Charts and Graphs
Speaking: SWOT Analysis on Oneself
Writing: Formal Letter Writing and Email Writing
Grammar: Perfect Tenses, Phrases and Clauses, Discourse Markers
Vocabulary : Verbal Analogy / Cloze Exercise

UNIT-IV **ENHANCING SPEAKING ABILITY** 6

Listening: Listening to eminent voices of one's interest (Martin Luther King, APJ Abdul Kalam, etc..)
Reading: Timed Reading, Filling KWL Chart.
Speaking: Just a Minute, Impromptu
Writing: Check-list, Instructions.
Grammar: 'Wh' Questions / 'Yes' or 'No' Questions, Imperatives
Vocabulary: Synonyms, Antonyms, Different forms of the same words.

UNIT-V **LANGUAGE FOR WORKPLACE** 6

Listening: Extensive Listening (Audio books, rendering of poems, etc.)
Reading: Extensive reading (Jigsaw Reading, Short Stories, Novels)
Speaking: Short Presentations on Technical Topics
Writing: Recommendations, Essay Writing
Grammar: Impersonal Passive, Reported Speech, Concord
Vocabulary : Informal Vocabulary and Formal Substitutes

Total Contact Hours: 30

Course Outcomes:

On completion of the course students will be able to

apply their comprehension skills and interpret different contents effortlessly

read and comprehend various texts and audio visual contents

infer data from graphs and charts and communicate it efficiently in varied contexts

participate effectively in diverse speaking situations

to present, discuss and coordinate with their peers in workplace using their language skills
SUGGESTED ACTIVITIES ● Ice breaker ● Just A Minute ● Ship wreck ● Hot seat ● Vocabulary building ● Chinese whispers ● Case study
SUGGESTED EVALUATION METHODS ● Assignment topics ● Quizzes ● Class Presentation/Discussion ● Continuous Assessment Tests
Text Book(s):
1. Effective Technical Communication by M. Ashraf Rizvi (Author) 2nd Edition Paperback 2017
2. Sylvan Barnet and Hugo Bedau, 'Critical Thinking Reading and Writing', Bedford/st. Martin's: Fifth Edition (June 28, 2004)
3. Meenakshi Upadhyay, Arun Sharma – Verbal Ability and Reading Comprehension.
4. Teaching Speaking: A Holistic Approach, Book by Anne Burns and Christine ChuenMeng Goh, Cambridge University Press
Reference Books(s) / Web links:
1. Basic Vocabulary in Use: 60 Units of Vocabulary Practice in North American English With Answers 2nd Edition by Michael McCarthy (Author), Felicity O'Dell (Author), John D. Bunting (Contributor)
2. Reading Development and Difficulties By Kate Cain
3. The 7 Habits of Highly Effective People by Stephen Covey, Simon and Schuster, UK
4. Everybody Writes: Your Go-To Guide to Creating Ridiculously Good Content Hardcover by Ann Handley (Author)

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	-	-	-	1	-	-	-	-	-	3	-	-	-	-	-
CO 2	-	-	-	1	-	-	-	-	-	3	-	-	-	-	-
CO 3	-	1	-	1	-	-	-	-	-	3	-	-	-	-	-
CO 4	-	-	-	2	-	-	-	-	1	3	-	-	-	-	-
CO 5	-	-	-	1	-	-	-	-	1	3	-	-	-	-	-
Average	**-**	**1**	**-**	**1.2**	**-**	**-**	**-**	**-**	**1**	**3**	**-**	**-**	**-**	**-**	**-**

Course Code	Course Title	Category	L	T	P	C
MA23111	**LINEAR ALGEBRA & CALCULUS**	**BS**	**3**	**1**	**0**	**4**

Common to I sem. B.E. – Computer Science and Engineering, Electrical and Electronics Engineering, Electronics and Communication Engineering, Biomedical Engineering & Computer Science and Engineering (Cyber Security) and B.Tech. – Information Technology

Objectives:

- To introduce the matrix techniques and to explain the nature of the matrix.
- To collect the matrix algebra techniques and the concepts of basis and dimension in vector spaces.
- To construct normalization of vectors and ortho-normal vectors.
- To understand techniques of calculus which are applied in the Engineering problems.
- To apply the techniques of Integration in finding area and volumes.

UNIT-I	MATRICES	12

Matrices - Eigenvalues and eigenvectors - Diagonalization of matrices using orthogonal transformation - Cayley-Hamilton Theorem(without proof) - Quadratic forms - Reduction to canonical form using orthogonal transformation - Numerical computation of Eigen value using Power method.

UNIT-II	LINEAR TRANSFORMATION	12
Vector spaces – Subspaces – Linear combinations and system of Linear equations – Linear independence and Linear dependence – Bases and Dimensions – Linear Transformation – Matrix representation of Linear Transformation - Null space, Range space and dimension theorem (without proof).		
UNIT-III	**INNER PRODUCT SPACES**	**12**
Inner product and norms - Gram Schmidt orthonormalization process - QR Factorization - Singular value decomposition.		
UNIT-IV	**FUNCTIONS OF SEVERAL VARIABLES**	**12**
Partial differentiation–Total derivative–Change of variables–Jacobians–Partial differentiation of implicit functions–Taylor's series for functions of two variables–Maxima and minima of functions of two variables–Lagrange's method of undetermined multipliers.		
UNIT-V	**MULTIPLE INTEGRALS**	**12**
Double integrals–Change of order of integration–Area enclosed by plane curves–Triple integrals–Volume of solids–Numerical computation of double integrals-trapezoidal rule.		
		Total Contact Hours: 60

Course Outcomes:

On completion of the course, students will be able to

- Demonstrate the matrix techniques in solving the related problems in engineering and technology.
- Apply the concepts of basis and dimension in vector spaces to the solution of related complex engineering problems.
- Construct orthonormal basis by the concepts of normalization in inner products and to analyse complex engineering problems.
- Interpret the problems in Engineering and Technology using the principles of mathematical calculus.
- Evaluate multiple integrals to conduct investigations of complex problems.

SUGGESTED ACTIVITIES

- Problem solving sessions
- Activity Based Learning
- Implementation of small module

SUGGESTED EVALUATION METHODS

- Problem solving in Tutorial sessions
- Assignment problems
- Quizzes and class test
- Discussion in classroom

Text Book(s):

1.	Grewal B.S., " Higher Engineering Mathematics ", Khanna Publishers, New Delhi, 43rd Edition, 2014.
2.	T Veerarajan , Linear Algebra and Partial Differential Equations, Mc Graw Hill Education,2019.
3.	Friedberg, A.H., Insel, A.J. and Spence, L., Elementary Linear Algebra, a matrix approach, 2nd edition, Pearson, 2014.
4.	T Veerarajan, Engineering Mathematics –I , McGraw Hill Education, 2018.
5.	Introduction to linear algebra, 5th Edition, Gilbert Strang, 2016. Wellesley Publishers.

Reference Books(s) / Web links:

1.	Ramana. B.V., " Higher Engineering Mathematics ", McGraw Hill Education Pvt. Ltd, New Delhi, 2018.
2.	Erwin Kreyszig ," Advanced Engineering Mathematics ", John Wiley and Sons, 10th Edition, New Delhi, 2016.
3.	Bali, N.P. and Manish Goyal, A Text Book of Engineering Mathematics, Lakshmi Publications Pvt. Ltd., New Delhi, 2006.
4.	Advanced Engineering Mathematics, (Seventh Edition), Peter V. O'Neil, Thomson Learning, 2020.
5.	Williams, G, "Linear Algebra with Applications", Jones & Bartlett Learning, First Indian Edition, New Delhi, 2017.

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	2	1	-	-	-	-	-	-	-	1	-	1	1	-
CO 2	3	3	-	-	-	-	-	-	-	-	-	-	1	1	-
CO 3	3	2	-	-	-	-	-	-	-	-	-	-	1	1	-
CO 4	2	2	-	-	-	-	-	-	-	-	1	1	1	1	-
CO 5	2	2	-	-	-	-	-	-	-	-	-	1	1	1	-
Average	**2.6**	**2.2**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**1**	**1**	**1**	**-**

Course Code	Course Title	Category	L	T	P	C
CY23131	CHEMISTRY FOR ELECTRONICS ENGINEERING	BS	3	0	2	4

Common to I sem. B.E. – Electronics and Communication Engineering, Biomedical Engineering and Electrical and Electronics Engineering
And
Common to II sem. B.E. - Mechatronics and Robotics & Automation

Objectives:

- To understand the principles of electrochemical processes
- To explore the functioning of sensors and their applications in industries and health care
- To get familiarized with the functioning of batteries and fuel cells
- To acquire knowledge on polymeric materials used in electronics
- To develop proficiency in nanomaterials

UNIT-I	DYNAMIC ELECTROCHEMISTRY	9

Applied Electrochemistry: Electrode Potential - EMF series - Corrosion- Causes, Consequences and Prevention. Surface Preparation- electropolishing -Electroplating of copper, electrophoretic deposition - Electrochemical machining, electrochemical etching - electrochemical etching of Cu from PCB.

UNIT-II	ELECTROCHEMICAL SENSORS	9

Electrodes - reference electrodes - ion-selective electrode, determination of electrode potential- Galvanic and concentration cells - potentiometric, amperometric and conductometric methods of analysis - potentiometric sensor, optical sensor, thermal sensor, chemical biosignals- sensors for health care – glucose and urea sensors, gas sensors for CO_2, O_2 and NH_3 sensing- blood oxygen sensor.

UNIT-III	ELECTROCHEMICAL ENERGY SYSTEMS	9

Batteries- types - characteristics-fabrication and working of lead-acid battery- NICAD battery – Nickel metal hydride batteries -lithium-ion battery - Supercapacitors- introduction - types - electrochemical double layer capacitor - activated carbon - carbon aerogels.

Fuel cells - classification – principle, working and applications of hydrogen-oxygen fuel cell - solid oxide fuel cell - direct methanol fuel cell and proton exchange membrane fuel cells-biofuel cells.

UNIT-IV	POLYMERS IN ELECTRONICS	9

Conducting polymers - **c**onducting mechanisms- polyaniline, Poly pyrrole - photonic polymers - photo resists - Introduction, Liquid crystalline phases, Identification of the mesophases, Lyotropic main chain liquid crystalline polymers, Thermotropic main chain liquid crystal polymers, Applications of liquid Crystals in Displays (LCDs) - Organic LEDs- functioning- advantages and disadvantages over conventional LEDs- commercial uses.

UNIT-V	NANO MATERIALS	9

Introduction-Types of nanomaterials-Emergence and challenges in nanotechnology- Synthesis routes for nanomaterials: Bottom-up and top-down approaches- Sol-gel, precipitation, Hydrothermal, Solvothermal, Microwave irradiation, Chemical Vapour Deposition (CVD), Electro deposition- Properties of nanomaterials- Mechanical properties, Chemical, Optical, Electrical and Magnetic properties-applications of nanomaterials.

Total Contact Hours: 45

Description of the Experiments	
1.	Construction and determination of EMF of simple electrochemical cells and concentration cells
2.	Estimation of acids by pH metry

3.	Determination of corrosion rate on mild steel by weight loss method
4.	Estimation of mixture of acids by conductometry
5.	Estimation of extent of corrosion of iron pieces by potentiometry
6.	Estimation of copper / ferrous ions by spectrophotometry
7.	Estimation of DO by using sensors
8.	Estimation of concentration of sulphate/chloride ions in the given sample solution.
9.	Determination of molecular weight of a polymer by viscometry method
10.	Synthesis of nanomaterials by simple precipitation method
	Total Contact Hours:30

Course Outcomes:

- Apply the knowledge of electrochemistry in exploring electrochemical processes.
- Associate the knowledge of sensors in health care and in pollution abatement
- Recognize the types of batteries and fuel cells
- Employ advanced materials in industrial applications and display techniques
- Develop nano and biomaterials for medical applications

SUGGESTEDACTIVITIES

- Electroplating process by group of students
- Ceramic coating on implant materials
- Electropolishing of metals and alloys

SUGGESTEDEVALUATIONMETHODS

- Continuous assessment tests
- Assignments
- Model lab examination
- End semester examination

Text Book(s):

1. P. C. Jain and Monika Jain, "Engineering Chemistry", DhanpatRai Publishing Company (P) Ltd, New Delhi, 2015
2. O.G.Palanna, "Engineering Chemistry", McGraw Hill Education (India) Pvt, Ltd, New Delhi, 2017
3. Shikha Agarwal "Engineering Chemistry-Fundamentals and applications", Cambridge University Press, New Delhi, 2015

Reference Books(s) / Web links:

- Gowarikar V. R., Viswanathan N.V. and Jayadev Sreedhar, ―Polymer Science, New Age International (P) Ltd., New Delhi, 2011
- Sujata V Bhat, "Biomaterials", Narosa Publishing House, New Delhi, 2002
- PradeepT, "A Text Book of Nanoscience and Nanotechnology", Tata McGraw Hill, New Delhi, 2012
- An Introduction to Nanomaterials and Nanoscience (PB 2020) : Asim K Das, Mahua Das, CBS publishers and distributors Pvt. Ltd.
- NPTEL course Elementary Electrochemistry course url **https://onlinecourses.nptel.ac.in/noc23_cy19/preview**
- For downloading text/reference books the weblink is given below can be used **http://libgen.rs/**

Lab equipment required:

S. No	Name of the Equipment	Quantity Required
1.	Oxygen sensors	10
2.	Ion selective electrodes for various ions in solution	10
3	Spectrophotometer	4
4	Magnetic stirrer with hot plate	10

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	2	2	1	-	-	-	-	-	-	-	-	1	-	-	-
CO 2	3	2	1	-	-	1	1	-	-	-	-	1	-	-	-
CO 3	2	1	1	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	2	1	1	-	-	-	-	-	-	-	-	1	-	-	-
CO 5	3	2	2	-	-	-	-	-	-	-	-	1	-	-	-
Average	**2.4**	**1.6**	**1.2**	**-**	**-**	**1`**	**1**	**-**	**-**	**-**	**-**	**1**	**-**	**-**	**-**

Course Code	**Course Title(Laboratory Integrated Theory Course)**	**Category**	**L**	**T**	**P**	**C**
GE23131	**PROGRAMMING USING C**	**ES**	**1**	**0**	**6**	**4**

Course Objectives:

- To develop simple algorithms for arithmetic and logical problems.
- To develop C Programs using basic programming constructs
- To develop C programs using arrays and strings
- To develop applications in C using functions , pointers and structures
- To develop applications using structures and union

List of Experiments

1.Overview of C, Constants, Variables and Data Types

2.Operators and Expressions, Managing Input and Output Operations

3.Decision Making and Branching

4.Decision Making and Looping

5.Nested Loops - while and for, Jumps in Loops

6.One-Dimensional Arrays

7.Pointers

8.Searching Algorithms - Linear and Binary

9.Sorting Algorithms - Bubble and Selection

10.Two-Dimensional and Multi-dimensional Arrays

11.Character Arrays and Strings Handling Functions

12.User-Defined Functions - Recursive Functions

13.Passing Arrays and Strings to Functions

14.Scope, Visibility and Lifetime of Variables

15.Structures and Unions

16.The Preprocessor

Total Contact Hours: 90

Platform Needed: GCC Compiler for Windows/Linux

Text Book(s):

1. Brian W. Kernighan and Dennis M. Ritchie, “The C Programming Language”, Second Edition, PHI publishers, 2017
2. Byron Gottfried, “Programming in C”, Second Edition, Schaum Outline Series, Tata McGraw - Hill Pub . Co. Ltd. , New Delhi , 1996

Reference Books(s) / Web links:

1. Herbert Schildt, “C: The Complete Reference”, Fourth Edition, McGraw Hill, 2003
2. YashavantKanetkar, “Let Us C”, BPB Publications, 15th Edition, 2016
3. E. Balaguruswamy, Programming in ANSI C, Tata McGraw-Hill, 8th Edition, 2019
4. NPTEL course , “Problem Solving Through Programming In C”, By Prof. Anupam Basu, IIT Kharagpur

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

- formulate simple algorithms for arithmetic and logical problems.

• implement conditional branching, iteration.
• decompose a problem into functions and synthesize a complete program.
• use arrays, pointers and structures to formulate algorithms and programs.
• apply programming to solve simple numerical method problems.
SUGGESTED ACTIVITIES: • Practice small and tricky codes • Practice problems in portals like Digital Café • Debugging the codes • Completing the function definitions etc

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	1	2	2	2	1	-	-	-	1	2	1	1	1	1	1
CO 2	1	1	1	1	1	-	-	-	-	-	1	1	1	1	1
CO 3	1	1	2	1	1	-	-	-	-	-	1	1	1	1	1
CO 4	2	2	3	2	1	-	-	-	1	-	2	1	1	1	1
CO 5	2	2	3	2	1	-	-	-	-	-	2	1	1	1	1
Average	**1.4**	**1.6**	**2.2**	**1.6**	**1.0**	**-**	**-**	**-**	**1.0**	**2.0**	**1.4**	**1.0**	**1.0**	**1.0**	**1.0**

Course Code	Course Title(Theory Course)	Category	L	T	P	C
GE23111	**ENGINEERING GRAPHICS**	**ES**	**2**	**0**	**4**	**4**

Objectives:

●	To understand the importance of the drawing in engineering applications
●	To develop graphic skills for communication of concepts, ideas and design of engineering products
●	To expose them to existing national standards related to technical drawings.
●	To improve their visualization skills so that they can apply this skill in developing new products.
●	To improve their technical communication skill in the form of communicative drawings

CONCEPTS AND CONVENTIONS (Not for Examination)		**1**
Importance of graphics in engineering applications–Use of drafting instruments– BIS conventions and specifications–Size, layout and folding of drawing sheets– Lettering and dimensioning. Basic Geometrical constructions.		
UNIT-I	**PLANE CURVES AND PROJECTION OF POINTS**	**5+12**
Curves used in engineering practices: Conics–Construction of ellipse, parabola and hyperbola by eccentricity method – Cycloidal Curves–Construction of cycloid, epicycloid and hypocycloid – Construction of involutes of square and circle–Drawing of tangents and normal to the above curves. Principles of Projection and Projection of points.		
UNIT-II	**PROJECTION OF LINES AND PLANE SURFACES**	**6+12**
Projection of straight lines (First angle projection) inclined to both the principal planes – Determination of true lengths and true inclinations by rotating line method. Projection of planes (polygonal and circular surfaces) inclined to both the principal planes by rotating object method.		
UNIT-III	**PROJECTION OF SOLIDS AND PROJECTION OF SECTIONED SOLIDS**	**6+12**
Projection of simple solids like prisms, pyramids, cylinder and cone when the axis is inclined to one of the principal planes by rotating object method. Sectioning of solids in simple vertical position when the cutting plane is inclined to HP and perpendicular to VP – obtaining true shape of the section. Practicing three-dimensional modeling of simple objects by CAD software (Not for examination)		
UNIT-IV	**DEVELOPMENT OF SURFACE AND ISOMETRIC PROJECTIONS**	**6+12**
Development of lateral surfaces of simple and sectioned solids – Prisms, pyramids cylinders and cones. Principles of isometric projection–isometric scale–Isometric projections of simple solids and truncated solids - Prisms, pyramids, cylinders and cones Model making of isometric projection of combination of solids as assignment (Not for End semester)		

UNIT-V	FREE HAND SKETCHING AND PERSPECTIVE PROJECTIONS	6+12
Free Hand sketching: Freehand sketching of multiple views from pictorial views of objects - Freehand sketching of pictorial views of object from multiple views Perspective projection of simple solids-Prisms, pyramids, cylinder and cone by visual ray method.		
	Total Contact Hours : L=30; T=60 (90 Periods)	

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

- construct different plane curves and to comprehend the theory of projection
- draw the basic views related to projection of lines and planes
- draw the projection of simple solids and to draw the projection of development of surfaces of Sectioned solids in simple vertical position
- draw the orthographic projection from pictorial objects and Isometric projections of simple solids
- visualize Perspective view of simple solids

Text Book (s):

1. Bhatt N.D. and Panchal V.M., "Engineering Drawing", Charotar Publishing House, 50th Edition, 2010.
2. Natarajan K.V., "A text book of Engineering Graphics", Dhanalakshmi Publishers, Chennai, 2017.

Reference Books(s) :

1. Varghese P I., "Engineering Graphics", McGraw Hill Education (I) Pvt.Ltd., 2013.
2. V.B Sikka "Civil Engineering Drawing", S.K Kataria & Sons, New Delhi.
3. Venugopal K. and PrabhuRaja V., "Engineering Graphics", New Age International (P)Limited, 2008.
4. Gopalakrishna K.R., "Engineering Drawing" (Vol. I&II combined), Subhas Stores, Bangalore, 2017.
5. Basant Agarwal and Agarwal C.M., "Engineering Drawing", McGraw Hill Publishing Company Limited, New Delhi, 2018.

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	2	2	1	-	1	-	2	2	2	-	2	-	-	-
CO 2	3	2	2	1	-	1	-	2	2	2	-	2	-	-	-
CO 3	3	2	2	1	-	1	-	2	2	2	-	2	-	-	-
CO 4	3	2	2	1	-	1	-	2	2	2	-	2	-	-	-
CO 5	3	2	2	1	-	1	-	2	2	2	-	2	-	-	-
Average	**3**	**2**	**2**	**1**	**-**	**1**	**-**	**2**	**2**	**2**	**-**	**2**	**-**	**-**	**-**

Course Code	Course Title(Laboratory Course)	Category	L	T	P	C
GE23122	**ENGINEERING PRACTICES - ELECTRICAL AND ELECTRONICS**	**ES**	**0**	**0**	**2**	**1**

Objectives:

- To provide hands-on experience on various basic engineering practices in Electrical Engineering.
- To provide hands-on experience on various basic engineering practices in Electronics Engineering.

List of Experiments

A. ELECTRICAL ENGINEERING PRACTICE

1. Residential house wiring using switches, fuses, indicators, lamp and energy meter.
2. Fluorescent lamp wiring.
3. Stair case wiring.
4. Measurement of electrical quantities – voltage, current, power & power factor in RL circuit.
5. Measurement of earth resistance using Megger.
6. Study of Ceiling Fan and Iron Box

B. ELECTRONICS ENGINEERING PRACTICE

1. Study of electronic components and equipment – Resistor, colour coding, measurement of AC signal parameters (peak-peak, rms period, frequency) using CRO/DSO.

2	(a) Measurement of electrical quantities using Multimeter (b) Testing of electronic components.
3	Study of logic gates : AND, OR, EXOR and NOT.
4	Generation of Clock Signals.
5	Soldering practice – Components Devices and Circuits – Using general purpose PCB.
6	Measurement of ripple factor of Half-wave and Full-wave Rectifiers.
	Total Contact Hours : 30

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

- fabricate the basic electrical circuits
- implement the house wiring circuits
- fabricate the electronic circuits
- verify the truth table of logic gates
- design the Half-wave and Full-wave Rectifiers using diodes and passive components

SUGGESTED EVALUATION METHODS

- Experiment based Viva

REFERENCE

1	Bawa H.S., "Workshop Practice", Tata McGraw – Hill Publishing Company Limited, 2007.
2	Jeyachandran K., Natarajan S. & Balasubramanian S., "A Primer on Engineering Practices Laboratory", Anuradha Publications, 2007.
3	Jeyapoovan T., Saravanapandian M. &Pranitha S., "Engineering Practices Lab Manual",Vikas Publishing House Pvt.Ltd, 2006.
4	Rajendra Prasad A. &Sarma P.M.M.S., "Workshop Practice", SreeSai Publication, 2002.

Lab Equipments Required:

S. No.	Name of the Equipment	Quantity Required
1	Residential house wiring using switches, fuse, indicator, lamp and energy	3 Nos
2	Fluorescent lamp wiring.	3 Nos
3	Stair case wiring	3 Nos
4	Measurement of electrical quantities – voltage, current, power & power factor	2 Nos
5	Study purpose items: Iron box, Ceiling fan.	2 each
6	Megger (250V/500V)	2 Nos.
7	Soldering guns	10 Nos.
8	Assorted electronic components for making circuits	50 Nos.
9	Small PCBs	10 Nos.
10	Multimeters	10 Nos.
11	Digital trainer kit	5 Nos.
12	CRO	8 Nos.
13	Transformer	8 Nos.
14	Function Generator	8 Nos.

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	2	-	-	2	-	3	2	-	3	3	3	2
CO 2	3	3	2	2	-	-	2	-	3	2	-	3	3	3	2
CO 3	3	3	3	2	-	-	2	-	3	2	-	3	3	3	2
CO 4	3	3	3	2	-	-		-	3	2	-	3	3	3	2
CO 5	3	3	3	2	-	-		-	3	2	-	3	3	3	2
Average	**3**	**3**	**2.67**	**2**	**-**	**-**	**2**	**-**	**3**	**2**	**-**	**3**	**3**	**3**	**2**

Course Code	Course Title	Category	L	T	P	C
MC23111	INDIAN CONSTITUTION AND FREEDOM MOVEMENT	MC	3	0	0	0

Common to I sem. B. E. – Computer Science and Engineering, Electronics and Communication Engineering, Electrical and Electronics Engineering & Computer Science and Design & Computer Science and Engineering (Cyber Security)
and
B.Tech. - Computer Science and Business Systems,
Artificial Intelligence and Machine Learning and Artificial Intelligence & Data Science
and
Common to II sem. B.E. – Aeronautical Engineering, Automobile Engineering, Biomedical Engineering, Civil Engineering, Mechanical Engineering, Mechatronics and Robotics & Automation
and
B.Tech. - Chemical Engineering, Food Technology & Information Technology
and
IV sem. - B.Tech. – Biotechnology.

Objectives:

- To apprehend the sacrifices made by the freedom fighters.
- To inculcate the values enshrined in the Indian constitution.
- To in stil a sense of responsibility as the citizens of India.
- To familiarise about the functions of the various levels of Government.
- To be informed about Constitutional and Non- Constitutional bodies.

UNIT-I	**INDIAN FREEDOM MOVEMENT**	9

British Colonialism in India-Colonial administration till 1857- Revolt of 1857- Early Resistance to British Rule-Rise of Nationalism in India-Indian Freedom Struggle under Mahatma Gandhi-Non- Cooperation Movement-Civil Disobedience Movement- Quit India Movement-British Official response to National movement- Independence of India Act 1947-Freedom and Partition.

UNIT-II	**CONSTITUTION OF INDIA**	9

Historical Background – Indian Constitution: Constitution' meaning of the term, Sources and constitutional history, Constituent Assembly of India – Philosophical foundations of the Indian Constitution – Preamble – Fundamental Rights – Directive Principles of State Policy – Fundamental Duties – Citizenship – Constitutional Remedies for citizens.

UNIT-III	**STRUCTURE AND FUNCTIONS OF CENTRAL GOVERNMENT**	9

Union Government – Structure of the Union Government and Functions – President – Vice President – Prime Minister – Cabinet – Parliament – Supreme Court of India – Judicial Review.

UNIT-IV	**STRUCTURE AND FUNCTION OF STATE GOVERNMENT AND LOCAL BODY**	9

State Government – Structure and Functions – Governor – Chief Minister – Cabinet – State Legislature – Judicial System in States – High Courts and other Subordinate Courts- Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation, Pachayati Raj: Introduction, Elected officials and their roles, Village level: Role of Elected and Appointed officials.

UNIT-V	**CONSTITUTIONAL FUNCTIONS AND BODIES**	9

Indian Federal System – Centre – State Relations – President's Rule – Constitutional Functionaries – Assessment of working of the Parliamentary System in India- CAG, Election Commission, UPSC, GST Council and other Constitutional bodies-. NITI Aayog, Lokpal, National Development Council and other Non –Constitutional bodies.

Total Contact Hours: 45

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

- appreciate the sacrifices made by freedom fighters during freedom movement.
- be responsible citizens and abide by the rules of the Indian constitution.
- be aware of the functions of the Indian government.
- be knowledgeable about the functions of the state Government and the Local bodies.
- apply the knowledge on constitutional functions and role of constitutional bodies and non-constitutional bodies.

SUGGESTED ACTIVITIES

- Famous speeches from around the world relating to independence
- Case study
- Quiz on Portfolio and Cabinet
- Discussions on International Associations like the UN, BRICS, QUAD
- Presentation on issues around the world

SUGGESTED EVALUATION METHODS

- Assignment topics
- Quizzes
- Class Presentation/Discussion
- Continuous assessments (CAT)

Text Book(s):

5. M. Laxmikanth , "Indian Polity:, McGraw-Hill, New Delhi.
6. Durga Das Basu, "Introduction to the Constitution of India ", Lexis Nexis, New Delhi. 21st ed 2013.
7. P K Agarwal and K N Chaturvedi ,PrabhatPrakashan, New Delhi, 1st ed , 2017.

Reference Books(s) / Web links:

1. Sharma, Brij Kishore, "Introduction to the Constitution of India:, Prentice Hall of India, New Delhi.
2. U.R.Gahai, "Indian Political System ", New Academic Publishing House, Jalaendhar
3. Bipan Chandra, India's Struggle for Independence, Penguin Books, 2016.
4. Maciver and Page, "Society: An Introduction Analysis ", Mac Milan India Ltd., New Delhi.2nd ed, 2014.
5. Bipan Chandra, History of Modern India, Orient Black Swan, 2009.

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	-	-	-	-	-	-	-	-		-	-	-	-	-	-
CO 3	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-
CO 4	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
CO 5	-	-	-	-	-	1	-	1	1	-	-	-	-	-	-
Average	-	-	-	-	-	1	-	1	1	-	-	-	-	-	-

GE23117 தமிழர் மரபு L T P C
1 0 0 1

அலகு I மொழி மற்றும் இலக்கியம்: 3

இந்திய மொழிக் குடும்பங்கள் - திராவிட மொழிகள் - தமிழ் ஒரு செம்மொழி - தமிழ் செவ்விலக்கியங்கள் - சங்க இலக்கியத்தின் சமய சார்பற்ற தன்மை - சங்க இலக்கியத்தில் பகிர்தல் அறம் - திருக்குறளில் மேலாண்மைக் கருத்துக்கள் - தமிழிக் காப்பியங்கள், தமிழகத்தில் சமண பௌத்த சமயங்களின் தாக்கம் - பக்தி இலக்கியம், ஆழ்வார்கள் மற்றும் நாயன்மார்கள் - சிற்றிலக்கியங்கள் - தமிழில் நவீன இலக்கியத்தின் வளர்ச்சி - தமிழ் இலக்கிய வளர்ச்சியில் பாரதியார் மற்றும் பாரதிதாசன் ஆகியோரின் பங்களிப்பு.

அலகு II மரபு - பாறை ஓவியங்கள் முதல் நவீன ஓவியங்கள் வரை - சிற்பக் கலை: 3

நடுகல் முதல் நவீன சிற்பங்கள் வரை - ஐம்பொன் சிலைகள் - பழங்குடியினர் மற்றும் அவர்கள் தயாரிக்கும் கைவினைப் பொருட்கள், பொம்மைகள் - தேர் செய்யும் கலை - சுடுமண் சிற்பங்கள் - நாட்டுப்புறத் தெய்வங்கள் - குமரிமுனையில் திருவள்ளுவர் சிலை - இசைக் கருவிகள் - மிருதங்கம், பறை, வீணை, யாழ், நாதஸ்வரம் - தமிழர்களின் சமூக பொருளாதார வாழ்வில் கோவில்களின் பங்கு.

அலகு III நாட்டுப்புறக் கலைகள் மற்றும் வீர விளையாட்டுகள்: 3

தெருக்கூத்து, கரகாட்டம், வில்லுப்பாட்டு, கணியான் கூத்து, ஒயிலாட்டம், தோல்பாவைக் கூத்து, சிலம்பாட்டம், வளரி, புலியாட்டம், தமிழர்களின் விளையாட்டுகள்.

அலகு IV தமிழர்களின் திணைக் கோட்பாடுகள்: 3

தமிழகத்தின் தாவரங்களும், விலங்குகளும் - தொல்காப்பியம் மற்றும் சங்க இலக்கியத்தில் அகம் மற்றும் புறக் கோட்பாடுகள் - தமிழர்கள் போற்றிய அறக்கோட்பாடு - சங்ககாலத்தில் தமிழத்தில் எழுத்தறிவும், கல்வியும் - சங்ககால நகரங்களும் துறை முகங்களும் - சங்ககாலத்தில் ஏற்றுமதி மற்றும் இறக்குமதி - கடல்கடந்த நாடுகளில் சோழர்களின் வெற்றி.

அலகு V இந்திய தேசிய இயக்கம் மற்றும் இந்திய பண்பாட்டிற்குத் தமிழர்களின் பங்களிப்பு: 3

இந்திய விடுதலைப்போரில் தமிழர்களின் பங்கு - இந்தியாவின் பிறப்பகுதிகளில் தமிழ்ப் பண்பாட்டின் தாக்கம் - சுயமரியாதை இயக்கம் - இந்திய மருத்துவத்தில், சித்த மருத்துவத்தின் பங்கு - கல்வெட்டுகள், கையெழுத்துப்படிகள் - தமிழ்ப் புத்தகங்களின் அச்சு வரலாறு.

TOTAL : 15 PERIODS

TEXT-CUM-REFERENCE BOOKS

1. தமிழக வரலாறு - மக்களும் பண்பாடும் - கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்).
2. கணினித் தமிழ் - 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.

SEMESTER II

Course Code	Course Title	Category	L	T	P	C
HS 23221	TECHNICAL COMMUNICATION II	HS	0	0	2	1

Common to all branches of II sem. B.E./ B.Tech. programmes

Objectives:

- To facilitate students to improve their vocabulary for a better communication
- To enable learners to understand and reproduce language
- To aid students to write technical reports in a convincing manner
- To expose students to different sentence structures
- To equip learners to present their ideas in an efficient manner

UNIT-I	**VOCABULARY FOR BETTER COMMUNICATION**	**6**

Listening: Telephonic Conversations and TV News
Reading: Newspapers and Magazines
Speaking: Conversational Practice: Speaking in a given situation, Asking permission and requesting etc..,
Writing: Job Application Letter and Resume
Grammar: Reference words: pronouns and determiners
Vocabulary: Guessing meanings of words in different contexts.

UNIT-II	**FUNCTIONAL LANGUAGE ASPECTS**	**6**

Listening: Motivational listening – listening to real life challenges
Reading: Articles and Technical reports
Speaking: Using Polite Expressions, Indirect Questions
Writing: Paraphrasing a Text, Poem
Grammar: Purpose Statements, Cause and Effect Expressions
Vocabulary: Neologisms.

UNIT-III	**TECHNICAL REPORTWRITING**	**6**

Listening: Empathetic Listening – Giving Solutions to Problems
Reading: Inferential Reading
Speaking: Dialogues – Interviewing Celebrities / Leaders / Sportspersons, etc..,
Writing: Report Writing
Grammar: Functional Usage of Expressions – used to, gone / been, etc..,
Vocabulary: Words Often Confused

UNIT-IV	**STRUCTURAL GRAMMAR**	**6**

Listening: Comprehension (IELTS practice tests)
Reading: Intensive Reading for specific information
Speaking: Pick and Talk
Writing: Proposals
Grammar: Sentence Structures – Simple, Compound, Complex Sentences
Vocabulary: Replacing dull words with vivid ones

UNIT-V	**PRESENTATION SKILLS**	**6**

Listening: Discriminative listening – sarcasm, irony, pun, etc..,
Reading: Practice of chunking – breaking up reading materials
Speaking: Mini presentation on some topic
Writing: Minutes of the meeting
Grammar: Correction of Errors
Vocabulary: Advanced vocabulary – fixing appropriate words in the given context.

Total Contact Hours: 30

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

- communicate effectively using appropriate vocabulary
- use the acquired language skills to comprehend various types of language contents
- evaluate different texts and write effective technical content
- use appropriate sentence structures to convey their thoughts in varied contexts
- present their concepts and ideas in an effective manner

SUGGESTED ACTIVITIES

- Story Lines
- One truth and two lies
- Hang Man
- Pictionary
- Word Scramble
- Case study

SUGGESTED EVALUATION METHODS

- Assignment topics
- Quizzes
- Class Presentation/Discussion
- Continuous Assessment Tests

Text Book(s):

1.	Raymond Murphy, "Intermediate English Grammar," Second Edition , Cambridge University Press, 2018
2.	Meenakshi Raman & Sangeeta Sharma, "Technical Communication" Third Edition, Oxford University Press, 2015
3.	Teaching Speaking: A Holistic Approach, Book by Anne Burns and Christine ChuenMeng Goh, Cambridge University Press

Reference Books(s) / Web links:

1.	Michael McCarthy (Author), Felicity O'Dell (Author), John D. Bunting (Contributor), "Basic Vocabulary in Use: 60 Units of Vocabulary Practice in North American English With Answers" 2nd Edition
2.	Dale Carnegie, "The Art of Public Speaking," Insight Press
3.	Jack C. Richards & Theodore S. Rodgers, " Approaches and Methods in Language Teaching, Second Edition, Cambridge University Press

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	-	-	-	1	-	-	-	-	-	2	-	-	-	-	-
CO 2	-	-	-	1	-	-	-	-	-	3	-	-	-	-	-
CO 3	-	2	-	1	-	-	-	-	-	3	-	-	-	-	-
CO 4	-	-	-	1	-	-	-	-	2	3	-	-	-	-	-
CO 5	-	-	-	1	-	-	-	-	2	2	-	-	-	-	-
Average	**-**	**2**	**-**	**1**	**-**	**-**	**-**	**-**	**2**	**2.6**	**-**	**-**	**-**	**-**	**-**

Course Code	Course Title	Category	L	T	P	C
HS23222	**ENGLISH FOR PROFESSIONAL COMPETENCE**	**HS**	**0**	**0**	**2**	**1**

Common to all branches of II sem. B.E./ B.Tech. programmes

Objectives:

- To facilitate the learners in acquiring listening and reading competence
- To enable the learners to communicate effectively through written and oral medium
- To assist the learners in preparing for competitive examinations
- To train the students in acquiring corporate skills
- To inculcate professional standards among the students and make them realize their responsibility in addressing the challenges

UNIT-I	RECEPTIVE SKILLS	6

Listening – Comprehensive Listening – Watching the news – Listening to a peer giving presentation, etc. – Critical Listening – Watching a televised debate, Listening to poems – **Reading** – Extensive Reading – Short stories and One-act Plays – Intensive Reading – Articles or Editorials in Magazines, Blog posts on topics like science and technology, arts, etc.

UNIT-II	PRODUCTIVE SKILLS	6

Speaking – Demonstrative Speaking – Process description through visual aids – Persuasive Speaking – Convincing the listener with the speaker's view – **Writing** – Descriptive Writing - Describing a place, person, process – Subjective Writing – Autobiography, Writing based on personal opinions and interpretations.

UNIT-III	ENGLISH FOR COMPETITIVE EXAMS	6

An introduction to International English Language Testing System (IELTS) – Test of English as a Foreign Language (TOEFL) – Graduate Record Examination (GRE) – Civil Service, Indian Economic Service Examination, Indian Statistical Service Examination, Combined Defence Services Examination, Staff Selection- (Language Related) – Aptitude tests.

UNIT-IV	CORPORATE SKILLS	6

Critical Thinking and Problem Solving – Case Study, Brainstorming, Q & A Discussion – **Team work and Collaboration** – Activities like Office Debates, Perfect Square, Blind Retriever, etc. – **Professionalism and Strong Work Ethics** – Integrity, Resilience, Accountability, Adaptability, Growth Mind set.

UNIT-V	PROJECT WORK	6

Case Study based on the challenges faced by the employers and the employees – Devise Plan, Provide Solution

Total Contact Hours: 30

Course Outcomes:

On completion of the course students will be able to

- interpret and respond appropriately in the listening and reading contexts.
- express themselves effectively in spoken and written communication
- apply their acquired language skills in writing the competitive examinations
- exhibit their professional skills in their work place
- identify the challenges in the work place and suggest strategies solutions

SUGGESTED ACTIVITIES

- Online Quizzes on Vocabulary
- Online Quizzes on grammar
- Communication Gap Exercises
- Presentations
- Word Building Games
- Case study

SUGGESTED EVALUATION METHODS

- Assignment topics
- Quizzes
- Class Presentation/Discussion
- Continuous Assessment Tests

Text Book(s):

1	How to Read Better & Faster, Norman Lewis, Goyal Publishers
2	Teaching Speaking: A Holistic Approach, Book by Anne Burns and Christine Chuen Meng Goh, Cambridge University Press
3	The Official Cambridge Guide To IELTS by Pauline Cullen, Cambridge University Press
4	The 7 Habits of Highly Effective People by Stephen Covey, Simon and Schuster, UK

Reference Books(s) / Web links:

1.	Board of Editors. Sure Outcomes. A Communication Skills Course for Undergraduate Engineers and Technologists. Orient Black Swan Limited, Hyderabad, 2013.
2.	Hartley, Mary. "The Power of Listening," JaicoPublishing House; First Edition (2015).
3.	Chambers, Harry. "Effective Communication Skills for Scientific and Technical Professionals," Persues Publishing, Cambridge, Massachusetts, 2000.

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	-	1	-	-	-	-	-	-	-	3	-	-	-	-	-
CO 2	-	1	-	-	-	-	-	-	-	3	-	-	-	-	-
CO 3	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
CO 4	-	-	-	-	-	-	2	2	-	3	-	-	-	-	-
CO 5	-	-	1	-	-	-	2	-	-	3	-	-	-	-	-

Average	**-**	**1**	**1**	**-**	**-**	**-**	**2**	**2**	**0**	**3**	**-**	**-**	**-**	**-**	**-**

Course Code	**Course Title**	**Category**	**L**	**T**	**P**	**C**
MA23212	**DIFFERENTIAL EQUATIONS AND COMPLEX VARIABLES**	**BS**	**3**	**1**	**0**	**4**

Common to II Sem. B.E. –Aeronautical Engineering, Automobile Engineering, Biomedical Engineering, Civil Engineering, Electrical and Electronics Engineering, Electronics and Communication Engineering, Mechanical Engineering, Mechatronics & Robotics & Automation
and
B. Tech. – Biotechnology, Food Technology & Chemical Engineering

Objectives:

- To provide students with an introduction to the theory of ordinary differential equations through applications, methods of solution, and numerical approximations.
- To introduce students to how to solve linear Partial Differential with different methods.
- To enable the students to study the Laplace Transforms, properties of Laplace Transform, inverse Laplace Transform and some applications to solve the differential equations and integral equations.
- To explain the concept of a vector integration in a plane and in space.
- To describe basic properties of complex variables and to have the ability to compute complex integrals.

UNIT-I	**ORDINARY DIFFERENTIAL EQUATIONS**	**12**

Second and higher order Linear differential equations with constant coefficients - Method of variation of parameters – Legendre's linear equations – Numerical solution of ODE - Single Step methods: Taylor's series method, Euler's method.

UNIT-II	**PARTIAL DIFFERENTIAL EQUATIONS**	**12**

Formation of partial differential equations - Classification of PDE – Solutions of standard types of first order partial differential equations - Lagrange's linear equation –Linear homogeneous partial differential equations of second and higher order with constant coefficients.

UNIT-III	**LAPLACE TRANSFORM**	**12**

Laplace transform –Basic properties – Transforms of derivatives and integrals of functions - Transforms of unit step function and impulse functions, periodic functions. Inverse Laplace transform – Problems using Convolution theorem – Solution of linear ODE of second order with constant coefficients using Laplace transformation techniques

UNIT-IV	**VECTOR CALCULUS**	**12**

Gradient, divergence and curl – Directional derivative – Irrotational and Solenoidal vector fields – Vector integration – Green's theorem in a plane, Gauss divergence theorem and Stokes' theorem (excluding proofs) – Simple applications involving cubes and rectangular parallelopipeds.

UNIT-V	**COMPLEX VARIABLES**	**12**

Analytic functions — Construction of analytic function - Bilinear transformation –Singularities – Cauchy's integral theorem (without proof) - Residues – Residue theorem (without proof) - Simple problems - Contour integral over $|z|=1$.

Total Contact Hours: 60

Course Outcomes:

On completion of the course students will be able to

- Apply the methods as a potent tool in the solution of a variety of problems in the natural sciences and technology.
- Develop specific methodologies, techniques and resources in Partial differential equations to conduct research and produce innovative results in the area of specialisation.
- Use Laplace transform and inverse transform techniques to solve the complex problems in engineering and technology.
- Apply the concepts in multivariable analysis, including space curves; directional derivative; gradient; multiple integrals; line and surface integrals; vector fields; divergence, curl ; the theorems of Green and Stokes, and the divergence theorem in different fields of engineering.
- Demonstrate the concept of Analytic functions, conformal mapping and complex integration in solving Engineering problems.

SUGGESTED ACTIVITIES

● Problem solving sessions ● Activity Based Learning
SUGGESTED EVALUATION METHODS ● Problem solving in Tutorial sessions ● Assignment problems ● Quizzes and class test ● Discussion in classroom

Text Book(s):	
1.	Grewal B.S., " Higher Engineering Mathematics ", Khanna Publishers, New Delhi, 43rd Edition, 2014.
2.	Veerarajan. T, Engineering Mathematics –II, Mc Graw Hill Education, 2018.
3.	Erwin Kreyszig," Advanced Engineering Mathematics ", John Wiley and Sons, 10th Edition, New Delhi, 2016.
4.	Glyn James, "Advanced Modern Engineering Mathematics", Pearson Education, 4th Edition, New Delhi, 2011.
5.	Jain R.K. and Iyengar S.R.K., "Advanced Engineering Mathematics", Narosa Publications, 5 th Edition, New Delhi, 2017.
Reference Books(s) / Web links:	
1.	Ramana. B.V., "Higher Engineering Mathematics ", McGraw Hill Education Pvt. Ltd, New Delhi, 2016.
2.	T Veerarajan, Transforms and Partial Differential Equations, Third Edition, 2018.
3.	Bali, N.P. and Manish Goyal, A Text Book of Engineering Mathematics, Lakshmi Publications Pvt. Ltd., New Delhi, 4th Edition 2006.
4.	Peter V.O'Neil, "Advanced Engineering Mathematics", Cengage Learning India Pvt., Ltd, 7th Edition, New Delhi, 2012.

COs/POs&PSOs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO 1	3	2	1	-	-	-	-	-	-	-	-	1	3	3	1
CO 2	3	2	1	-	-	-	-	-	-	-	-	1	3	3	1
CO 3	3	2	1	-	-	-	-	-	-	-	-	-	3	3	1
CO 4	2	2	1	-	-	-	-	-	-	-	-	-	3	3	1
CO 5	3	2	1	-	-	-	-	-	-	-	-	1	3	3	1
Average	**2.8**	**2**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**3**	**3**	**1**

Course Code	**Course Title**	**Category**	**L**	**T**	**P**	**C**
PH23232	**PHYSICS FOR ELECTRONICS ENGINEERING**	**BS**	**3**	**0**	**2**	**4**

Common to II sem. B.E. – Electronics and Communication Engineering & Electrical and Electronics Engineering

Objectives:

- To understand the essential principles of electron transport properties.
- To impart the knowledge on the properties of semiconductors.
- To become proficient in magnetic, superconducting and dielectric properties of materials.
- To expose the properties and applications of optical materials.
- To enhance the fundamental knowledge on quantum confinement and nano based devices.

UNIT-I	**ELECTRICAL PROPERTIES OF MATERIALS**	**9**

Classical free electron theory - expression for electrical conductivity - electrons in metals –Introduction to quantum physics-wave function-Schrodinger equation- particle in a box-one dimension - degenerate states - Fermi Dirac statistics - density of energy states – Quantum mechanical theory of electrical conductivity- electron effective mass – concept of hole.

UNIT-II	**SEMICONDUCTOR PHYSICS**	**9**

Intrinsic semiconductors - energy band diagram - direct and indirect semiconductors - carrier concentration in intrinsic semiconductors-Band gap determination –extrinsic semiconductors - carrier concentration in N-type and P-type semiconductors. Hall effect-determination of Hall co-efficient and applications. PN and Metal–Semiconductor Junctions: Energy band diagram and Depletion Layer of a PN Junction, Built-in potential, Carrier injection under forward bias.		
UNIT-III	**MAGNETIC, SUPERCONDUCTOR AND DIELECTRIC PROPERTIES OF MATERIALS**	**9**
Magnetism in materials - magnetic field and induction - magnetization - magnetic permeability and susceptibility - types of magnetic materials - microscopic classification of magnetic materials. Ferromagnetism: domain theory. Superconductor: critical temperature, zero electric resistance, Meissner effect and critical magnetic field. Dielectric materials: Polarization processes - internal field -dielectric loss -high-k dielectrics.		
UNIT-IV	**OPTOELECTRONICS**	**9**
Classification of optical materials - carrier generation and recombination processes. Absorption, emission and scattering of light in metals, insulators and semiconductors (concepts only). Solar cell - photo detectors - LED - Organic LED – laser diodes - NLO materials-properties and applications.		
UNIT-V	**NANOELECTRONIC DEVICES**	**9**
Introduction - size dependence of Fermi energy- quantum confinement - quantum structures. quantum well, quantum wire and quantum dot structures. Tunnelling-Coulomb blockade effects - single electron phenomena and single electron transistor - magnetic semiconductors–spintronics - Quantum computing basics of q-bits, superposition and quantum entanglement (qualitative), MEMS: Cantilever.		
Total Contact Hours: 45		

Description of the Experiments	
1.	Determination of Planck's constant using colour LED
2.	Determination of Band gap of semiconducting material.
3.	Determination of Hall coefficient of semiconductor.
4.	Determine the hysteresis loss in the transformer core using B-H curve unit.
5.	Determination of free space permeability using Helmholtz coil.
6.	Determination of magnetic susceptibility of ferrous liquid using Quincke's Method.
7.	Determination of Resonance frequency of LCR series circuit.
8.	Determination of wavelength of diode laser using diffraction grating.
9.	Determination of fill factor of solar cell.
10.	Determination of quantum efficiency of photo diode from I-V Characteristic curve.

Total Contact Hours:30

Course Outcomes:

On completion of the course, students will be able to

- apply the concept of electron transport in devices.
- analyse the physical properties of semiconductors.
- analyse the properties of magnetic and dielectric materials.
- analyse the properties of optical materials used for optoelectronics.
- analyse the quantum behaviour of semiconductor MEMS and nanoelectronic devices.

SUGGESTED ACTIVITIES

- Problem solving sessions

SUGGESTED EVALUATION METHODS

- Quizzes
- Class Presentation / Discussion

Text Book(s):

6. Kasap, S.O. Principles of Electronic Materials and Devices, McGraw-Hill Education, 2017.
7. Wahab, M.A. Solid State Physics: Structure and Properties of Materials. Narosa Publishing House, 2020.

Reference Books(s) / Web links:

1. Garcia, N. & Damask, A. Physics for Computer Science Students: with emphasis on Atomic and Semiconductor Physics. Springer-Verlag, 2012.
2. Hanson, G.W. Fundamentals of Nanoelectronics. Pearson Education, 2009.
3. Rogers, B., Adams, J. & Pennathur, S. Nanotechnology: Understanding Small Systems. CRC Press, 2014.
4. S. O. Pillai, Solid State Physics (Multi colour Edition) , New Age International, 2018.

5	Umesh K Mishra & Jasprit Singh, Semiconductor Device Physics and Design, Springer, 2008.

List of Equipment Available

(Common to B.E. ECE and EEE)

S. No	Name of the equipment	Quantity Required	Quantity Available	Deficiency
1	Band gap of a semiconductor setup	8	19	-
2	Hall coefficient of semiconductor setup	4	4	-
3	B-H curve setup and CRO	6	7	-
4	Determination of permeability of free space - Helmholtz coil setup	5	5	-
5	Magnetic Susceptibility– Quincke's tube, Electromagnet, Power supply Traveling Microscope	4	4	-
6	LCR circuit kit	7	7	-
7	Solar cell parameters setup	6	8	-
8	Determination of Plank's constant - Rheostat, Multimeter, LED	8	10	-
9	Photo diode Characteristics.	6	6	-
10	Wavelength of Laser and Characteristics -Laser source and grating plate.	6	15	-

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	2	-	-	-	-	-	-	-	-	-	-	2	-	-
CO 2	3	2	1	-	-	-	-	-	-	-	-	1	2	-	-
CO 3	3	2	1	-	-	-	-	-	-	-	-	-	2	-	-
CO 4	3	2	1	-	-	-	-	-	-	-	-	1	2	-	-
CO 5	3	2	1	-	-	-	-	-	-	-	-	1	2	-	-
Average	**3**	**2**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**2**	**-**	**-**

Course Code	Course Title(Laboratory Integrated Theory Course)	Category	L	T	P	C
CS23231	**DATA STRUCTURES**	**ES**	**3**	**0**	**4**	**5**

Objectives:

- To apply the concepts of Linked List in the applications of various linear data structures.
- To demonstrate the understanding of stacks, queues and their applications.
- To apply the concepts of Linked List in the applications of various nonlinear data structures.
- To understand the implementation of graphs and their applications.
- To be able to incorporate various sorting and hashing techniques in real time scenarios

UNIT-I	**LINEAR DATA STRUCTURES –LIST**	**9**
Self-Referential Structures, Dynamic Memory Allocation, Linked list implementation - Singly Linked List, Doubly Linked List, Circular Linked List, Applications of List.		
UNIT-II	**LINEAR DATA STRUCTURES –STACK AND QUEUE**	**8**
Stack – Operations, Array and Linked list implementation, Applications – Evaluation of Arithmetic Expressions, Queues-Operations, Array and Linked list Implementation.		
UNIT-III	**NONLINEAR DATA STRUCTURES –TREES**	**10**
Tree Terminologies, Binary Tree Representation, Tree Traversals, Binary Search Trees, Binary Heap, Height Balance Trees – AVL Trees.		
UNIT-IV	**NONLINEAR DATA STRUCTURES –GRAPHS**	**9**
Representation of Graphs, Topological Sort, Depth First Search and Breadth-First Search , Minimum Spanning Tree – Prim's Algorithm, Shortest path algorithm – Dijikstra's Algorithm.		
UNIT-V	**SEARCHING, SORTING AND HASHING TECHNIQUES**	**9**

Sorting Techniques –Insertion Sort, Quick Sort, Merge Sort, Hashing- Hashing functions – Mid square, Division, Folding, Collision Resolution Techniques – Separate Chaining – Open Addressing – Rehashing.			
	Contact Hours	**:**	**45**
Course Outcomes: At the end of the course, students will be able to			
•	understand and apply the various concepts of Linear data Structures		
•	understand and apply the various concepts of Non Linear data Structures.		
•	understand and apply the various sorting and Hashing concepts.		
•	analyse and apply the suitable data structure for their research.		
•	choose efficient data structures and apply them to solve real world problems.		
SUGGESTED ACTIVITIES • Role play- Linked List (Unit 1). • Mind Map, Poster Design - Stack and Queue (Unit 2). • Flipped Classroom - Binary Heap (Unit 3). • Poster Design - Graph (Unit4). • Implementation of small module- Hashing (Unit5).			
SUGGESTED EVALUATION METHODS • Assignment problems - Linked List (Unit 1). • Tutorial problems - Applications – Evaluation of Arithmetic Expressions (Unit 2). • Quizzes - BST and Binary Heap (Unit 3). • Tutorial problems- Graph traversal (Unit 4). • Quizzes - Hashing and Sorting(Unit5) .			
Text Book(s):			
1.	"Data Structures and Algorithm Analysis in C", Mark Allen Weiss, 2nd Edition, Pearson Education, 2005		
2.	"Data Structures and Algorithm Analysis in C++ - Anna University, Mark Allen Weiss, Pearson Education, 2017.		
Reference Books(s) :			
1.	"Data Structures Using C and C++", Langsam, Augenstein and Tanenbaum, 2nd Edition, Pearson Education, 2015.		
2.	Thomas H. Cormen, Charles E. Leiserson, Ronald L.Rivest, Clifford Stein, Introduction to Algorithms", Fourth Edition, Mcgraw Hill/ MIT Press, 2022.		
Web links for Theory & Lab(if any)			
1.	Data Structures - GeeksforGeeks		
2.	Data Structures | DS Tutorial - javatpoint		
3.	Data Structure and Types (programiz.com)		
Lab Experiments			
1	Implementation of Single Linked List (Insertion, Deletion and Display).		
2	Implementation of Doubly Linked List (Insertion, Deletion and Display).		
3	Implementation of Stack using Array and Linked List implementation.		
4	Implementation of Queue using Array and Linked List implementation.		
5	Implementation of Binary Search Tree and perform Tree Traversal Techniques.		
6	Program to perform Quick Sort		
7	Program to perform Merge Sort		
8	Program to perform Linear Probing.		
9	Program to perform Rehashing.		
10	Mini Project: • Contact book application using Linked List. • Dictionary using Binary search trees. • Snake Game. • Chess Game. • Travel Planner (Shortest Path Algorithm). • Tic-Tac-Toe Game. • Library Management System. • Project Management System. • other projects		
	Contact Hours	**:**	**60**
	Total Contact Hours	**:**	**105**
Course Outcomes: On completion of the course, the students will be able to			
•	analyze the various data structure concepts.		
•	implement Stacks and Queue concepts for solving real-world problems.		
•	analyze and structure the linear data structure using tree concepts.		

•	critically analyse various non-linear data structures algorithms.
•	apply different Sorting, Searching and Hashing algorithms.

COs/POs& PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	1	2	1	2	1	-	-	-	-	-	-	1	1	1	1
CO 2	1	1	2	1	1	-	-	-	-	-	-	2	1	1	1
CO 3	1	1	2	1	1	-	-	-	-	-	-	2	1	1	1
CO 4	1	1	2	1	1	-	-	-	-	-	-	2	1	1	1
CO 5	1	1	2	1	1	-	-	-	-	-	-	1	1	1	1
Average	**1.0**	**1.2**	**1.8**	**1.2**	**1.0**	**-**	**-**	**-**	**-**	**-**	**-**	**1.6**	**1.0**	**1.0**	**1.0**

Course Code	**Course Title(Theory Course)**	**Category**	**L**	**T**	**P**	**C**
EE23212	**ELECTRIC CIRCUITS**	**PC**	**3**	**0**	**0**	**3**

Objectives:

- To introduce DC circuits and provide knowledge on their analysis.
- To introduce AC circuits and impart knowledge on their analysis.
- To familiarise the phenomenon of resonance in series and parallel circuits.
- To impart knowledge on obtaining the transient response of RC, RL and RLC circuits.
- To provide knowledge on the analysis of three phase circuits with balanced and unbalanced loads.

UNIT-I **ANALYSIS OF DC CIRCUITS** **9**

Electrical circuit elements – Ohm's Law – V-I Characteristics (linear and non-linear elements) - Kirchhoff's laws – Resistors in series and parallel– Voltage and Current division method - Star Delta conversion - Source transformation - Mesh current and Nodal voltage methods of analysis – Network reduction using circuit theorems: Thevenin's and Norton's Theorems – Superposition Theorem – Maximum power transfer theorem – Reciprocity Theorem.

UNIT-II **ANALYSIS OF AC CIRCUITS** **9**

Average and RMS Values of alternating current waveforms – R, L, C, RL, RC and RLC circuits - Impedance and Admittance – Power, Power Factor – Phasor diagram - Network reduction using circuit theorems for AC circuits – Analysis of two port networks - Impedance and admittance parameters.

UNIT-III **RESONANCE AND COUPLED CIRCUITS** **9**

Series and parallel resonance –frequency response – Quality factor and Bandwidth - Self and mutual inductance – Coefficient of coupling – Single Tuned Circuits.

UNIT-IV **TRANSIENT RESPONSE OF DC AND AC CIRCUITS** **9**

Transient response of RL, RC and RLC Circuits using Laplace transform for DC and AC sinusoidal inputs.

UNIT-V **THREE PHASE CIRCUITS** **9**

Analysis of three phase 3-wire and 4-wire star circuits - delta circuits , balanced & unbalanced three phase loads - phasor diagram of voltages and currents – power and power factor measurements in three phase circuits.

Total Contact Hours : 45

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

- analyse DC circuits and apply circuit theorems
- examine AC circuits using circuit theorems and analyze two port networks.
- analyse series and parallel resonant circuits
- obtain the transient response of DC and AC Circuits
- evaluate power in three phase circuits for balanced and unbalanced loads

Suggested Activities

- Homework Problems
- Synthesizing Circuit Components based on given specifications

Suggested Evaluation Methods	
●	Seminar Presentation
●	Group Assignments
Text Book (s):	
1	William H. Hayt Jr, Jack E. Kemmerly and Steven M. Durbin, "Engineering Circuits Analysis", Tata McGraw Hill publishers, 8th edition, New Delhi, 2013.
2	Joseph A. Edminister, Mahmood, Nahri, "Electric Circuits" – Schaum Series and Systems", Schaum"s Outlines, Tata McGrawHill, Indian. 5th Edison , 2017
3	Sudhakar A and Shyam Mohan SP, "Circuits and Network Analysis and Synthesis", Tata McGraw Hill, 2015
4	Charles K. Alexander, Mathew N.O. Sadiku, "Fundamentals of Electric Circuits", Sixth Edition, McGraw Hill,2019.
Reference Books(s) :	
1	Chakrabati A, "Circuits Theory (Analysis and synthesis), Dhanpat Rai & Sons, New Delhi, 2013.
2	J. David Irwin, R. Mark Nelms with Amalendu Patnaik. "Engineering Circuit Analysis", 11th Edition, Wiley Publishers, 2015
3	Allan H. Robbins, Wilheim C. Miller, "Circuit Analysis: Theory and Practice", 5th Edition, Cengage publishers, 2013
Web links :	
1	NPTEL :: Electrical Engineering - NOC:Basic Electric Circuits
2	Example videos in www.circuitlab.com

COs/POs& PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	2	2	-	-	-	3	2	-	-	3	1	3
CO 2	3	3	3	2	2	-	-	-	3	2	-	2	3	1	3
CO 3	2	3	3	2	2	-	-	-	3	2	-	-	3	1	3
CO 4	3	3	3	2	2	-	-	-	3	2	-	-	3	1	3
CO 5	3	3	2	2	2	-	-	1	3	2	-	2	3	3	3
Average	**2.8**	**3**	**2.8**	**2**	**2**	**-**	**-**	**1**	**3**	**2**	**-**	**2**	**3**	**1.4**	**3**

Course Code	Course Title(Laboratory Course)	Category	L	T	P	C
EE23221	**ELECTRIC CIRCUITS LABORATORY**	**PC**	**0**	**0**	**2**	**1**

Objectives:	
●	To experimentally verify Kirchhoff's laws.
●	To understand the network theorem in DC circuits.
●	To verify the phenomenon of resonance in AC circuits.
●	To obtain the transient response of RL and RC circuits.
●	To understand the concepts of three phase circuits.
List of Experiments	
1	Kirchhoff's laws
2	Network theorems (Thevenin's, Norton's, Superposition and Maximum power transfer Theorem).
3	Frequency response of RL, RC and RLC circuits.
4	Determination of time constant of series RL and RC circuits through simulation and experimentation.
5	Determination of time constant of parallel RL and RC circuits through simulation and experimentation.
6	Determination of coefficient of coupling of a single phase transformer.
7	Relation between line and phase quantities in three phase balanced star connected load.
8	Relation between line and phase quantities in three phase balanced delta connected load.
9	Experimental determination of power in three phase circuits by two-wattmeter method.

10	Simulation of three-phase balanced and unbalanced star delta networks circuits.			
		Total Contact Hours	**:**	**30**

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

- analyse DC circuits using Kirchhoff's laws.
- apply circuit theorems for DC circuits.
- analyse coupled circuits, series and parallel resonant circuits.
- obtain the transient response of DC circuits.
- realise the concept of three phase AC circuits and to evaluate its power.

Suggested Evaluation Methods

- Experiment based viva
- Quizzes

Lab Equipments Required:

S. No.	Name of the Equipment	Quantity Required
1	Dual DC Regulated Power Supply (0 – 30 V)	15 Nos.
2	Digital Function Generator (2 MHz) with Probes	10 Nos.
3	Digital Storage Oscilloscope (20 MHz) with Probes	10 Nos.
4	Single Phase autotransformer	3 Nos.
5	Single Phase transformer	3 Nos.
6	DC Ammeter (Various Ranges)	15 Nos.
7	DC Voltmeter (Various Ranges)	15 Nos.
8	AC Ammeter (Various Ranges)	10 Nos.
9	AC Voltmeter (Various Ranges)	10 Nos.
10	Single Phase Wattmeter - 600V, 10A,UPF	3 Nos.
11	Solder less Breadboard	15 Nos.
12	Digital Multimeter	5 Nos.
13	Decade Resistance Box, Decade Inductance Box, Decade Capacitance Box	5 Nos. Each
14	Variable 3Ø Resistive load	3 Nos.
15	Circuit Simulation Software with PC	5 Nos.
16	Printer	1 No.
17	Necessary Quantities of Resistors, Inductors, Capacitors of various capacities (Quarter Watt to 10 watt)	
18	Single strand Connecting wires	

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	2	2	-	-	-	3	2	-	-	3	1	3
CO 2	3	3	3	2	2	-	-	-	3	2	-	2	3	1	3
CO 3	2	3	3	2	2	-	-	-	3	2	-	-	3	1	3
CO 4	3	3	3	2	2	-	-	-	3	2	-	-	3	1	3
CO 5	3	3	2	2	2	-	-	1	3	2	-	2	3	3	3
Average	**2.8**	**3**	**2.8**	**2**	**2**	**-**	**-**	**1**	**3**	**2**	**-**	**2**	**3**	**1.4**	**3**

Course Code	Course Title(Laboratory Course)	Category	L	T	P	C
GE23121	**ENGINEERING PRACTICES – CIVIL AND MECHANICAL**	**ES**	**0**	**0**	**2**	**1**

Objectives:

To provide exposure to the students with hands on experience on various basic engineering practices in Civil and Mechanical Engineering.

List of Experiments

CIVIL ENGINEERING PRACTICE

1.	Study of pipeline joints, its location and functions: valves, taps, couplings, unions, reducers, and elbows in household fittings.
2.	Preparation of basic plumbing line sketches for wash basins, water heaters, etc.
3.	Hands-on-exercise: Basic pipe connections – Pipe connections with different joining components.
Carpentry Works:	
4.	Study of joints in roofs, doors, windows and furniture.
5.	Hands-on-exercise: Woodwork, joints by sawing, planning and chiselling.
MECHANICAL ENGINEERING PRACTICE	
6.	Preparation of butt joints, lap joints and T- joints by Shielded metal arc welding.
7	Gas welding practice.
Basic Machining:	
8	Simple Turning and Taper turning
9	Drilling Practice
Sheet Metal Work:	
10	Forming & Bending:
11	Model making – Trays and funnels
12	Different type of joints.
Machine Assembly Practice:	
13	Study of centrifugal pump
14	Study of air conditioner
	Total Contact Hours : 30

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

●	perform plumbing activities for residential and industrial buildings considering safety aspects while gaining clear understanding on pipeline location and functions of joints like valves, taps, couplings, unions, reducers, elbows, etc.
●	perform wood working carpentry activities like sawing, planning, cutting, etc. while having clear understanding of the joints in roofs, doors, windows and furniture.
●	produce joints like L joint, T joint, Lap joint, Butt joint, etc. through arc welding process while acquiring in depth knowledge in the principle of operation of welding and other accessories
●	perform operations like Turning, Step turning, Taper turning, etc. in lathe and Drilling operation in drilling machine
●	perform sheet metal operations like Forming, Bending, etc. and fabricating models like Trays, funnels, etc.

List of equipment and components

(For a Batch of 30 Students)

CIVIL

1. Assorted components for plumbing consisting of metallic pipes, plastic pipes, flexible pipes, couplings, unions, elbows, plugs and other fittings - 15 Sets.
2. Plumbing vice (fitted to work bench) – 15 Nos.
3. Carpentry vice (fitted to work bench) - 15 Nos.
4. Standard woodworking tools - 15 Sets.
5. Models of industrial trusses, door joints, furniture joints - 5 each
6. Power Tools: (a) Rotary Hammer - 1 No. (b) Circular Saw - 1 No. (c) Electric Planer - 1 No. (d) Hand Drilling Machine - 1 No. (e) Jigsaw - 1 No. (f) Cutoff Machine – 1 No.

MECHANICAL

1. Arc welding transformer with cables and holders - 5 Nos.
2. Welding booth with exhaust facility - 5 Nos.
3. Welding accessories like welding shield, chipping hammer, wire brush, etc. - 5 Sets.
4. Oxygen and acetylene gas cylinders, blow pipe and other welding outfit - 1 No.
5. Centre lathe - 5 Nos.
6. Standard Sheet metal working tools – 2 sets
7. Study-purpose items: centrifugal pump, air-conditioner – 1 each.

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3

CO 1	1	1	1	-	-	2	1	-	2	-	-	2	-	-	-
CO 2	1	1	1	-	-		1	-		-	-		-	-	-
CO 3	1	1	1	-	-	2	1	-	2	-	-	2	-	-	-
CO 4	1	1	1	-	-	2	1	-	2	-	-	2	-	-	-
CO 5	1	1	1	-	-	2	1	-	2	-	-	2	-	-	-
Average	**1**	**1**	**1**	**-**	**-**	**2**	**1**	**-**	**2**	**-**	**-**	**2**	**-**	**-**	**-**

Course Code	Course Title	Category	L	T	P	C
MC23112	ENVIRONMENTAL SCIENCE AND ENGINEERING	MC	3	0	0	0

Common to I sem. B.E. Aeronautical Engineering, Automobile Engineering, Biomedical Engineering, Civil Engineering, Mechanical Engineering, Mechatronics, and Robotics and Automation

and

B.Tech. – Biotechnology, Information Technology, Food Technology & Chemical Engineering

and

Common to II sem. B.E. – Electronics and Communication Engineering, Electrical and Electronics Engineering, Computer Science and Engineering, Computer Science and Design & Computer Science and Engineering (Cyber Security)

and

B.Tech. – Artificial Intelligence & Machine Learning and Artificial Intelligence & Data Science.

Objectives:

- To develop the understanding of environmental and associated issues
- To develop an attitude of concern for the environment
- To promote enthusiasm in participating environmental protection initiatives
- To nurture skills to solve environmental degradation issues
- To develop the knowledge about the environmental laws

UNIT-I	**AIR AND NOISE POLLUTION**	9

Definition –sources of air pollution –chemical and photochemical reactions in the atmosphere - formation of smog, PAN, acid rain, ozone depletion, particulate pollutants-Air quality standards-Air quality indices - control of particulate air pollutants-gravitational settling chambers, cyclone separators, wet collectors, fabric filters (Bag-house filter), electrostatic precipitators (ESP)-catalytic converters.

Noise pollution –sources - health effects - standards- measurement and control methods.

UNIT-II	**WATER POLLUTION AND ITS MANAGEMENT**	9

Definition-causes-effects of water pollution-point and nonpoint sources of wastewater-marine pollution - thermal pollution - Control of water pollution by physical, chemical and biological methods – wastewater treatment-primary, secondary and tertiary treatment-sources and characteristics of industrial effluents- zero liquid discharge.

UNIT-III	**SOLID WASTE AND HAZARDOUS WASTE MANAGEMENT**	9

Solid waste – types- municipal solid waste management: sources, characteristics, collection, and transportation-sanitary landfill, recycling, composting, incineration, energy recovery options from waste - Hazardous waste – types, characteristics, and health impact - hazardous waste management: neutralization, oxidation reduction, precipitation, solidification, stabilization, incineration and final disposal.

E-waste-definition-sources-effects on human health and environment- E-waste management- steps involved - Role of E-waste management within the initiatives of the Govt. of India- Swachh Bharat Mission.

UNIT-IV	**SUSTAINABLE DEVELOPMENT**	9

Sustainable development- concept-dimensions-sustainable development goals - value education- gender equality – food security - poverty – hunger - famine - Twelve principles of green chemistry - Green technology - definition, importance - Cleaner development mechanism - carbon credits, carbon trading, carbon sequestration, eco labeling-International conventions and protocols-Disaster management.

UNIT-V	**ENVIRONMENTAL MANAGEMENT AND LEGISLATION**	9

Environmental Management systems - ISO 14000 series- Environmental audit-Environmental Impact Assessment- life cycle assessment- h uman health risk assessment - Environmental Lawsand Policy- Objectives - Polluter pays principle, Precautionary principle - The Environment (Protection) Act 1986 - Role of Information technology in environment and human health.
Total Contact Hours:45
Course Outcomes: On completion of the course, the students will be able to
● Associate air and noise quality standards with environment and human health.
● Illustrate the significance of water and devise control measures for water pollution.
● Analyze solid wastes and hazardous wastes.
● Outline the goals of sustainable development in an integrated perspective.
● Comprehend the significance of environmental laws.
SUGGESTED EVALUATION METHODS ● Continuous assessment tests ● Assignments ● Case studies, class room presentations (or) site visit
Text Book(s):
3. Benny Joseph, 'Environmental Science and Engineering', Tata McGraw-Hill, New Delhi, 2016
4. Anubha Kaushik and C. P. Kaushik's "Perspectives in Environmental Studies", 6th Edition, New Age International Publisher, 2018.
5. Johri R., E-waste: implications, regulations, and management in India and current global best practices, TERI Press, New Delhi
Reference Books(s) / Web links:
● R.K. Trivedi, 'Handbook of Environmental Laws, Rules, Guidelines, Compliances and Standards', Vol. I and II, Enviro Media. 38. Edition 2010.
● Cunningham, W.P. Cooper, T.H. Gorhani, 'Environmental Encyclopedia', Jaico Publ., House, Mumbai, 2001.
● Fowler B, Electronic Waste – 1 st Edition (Toxicology and Public Health Issues), 2017 Elsevier
● NPTEL course urlhttps://onlinecourses.nptel.ac.in/noc19_ge22/NPTEL https://news.mit.edu/2013/ewaste-mit
1. For downloading text/reference books the weblink is given below can be used **http://libgen.rs/**

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	1	2	3	1	-	2	2	2	1	1	1	2	-	1	-
CO 2	1	2	3	1	-	2	2	2	1	1	1	2	-	1	-
CO 3	-	-	3	1	-	2	3	2	1	-	1	2	-	-	-
CO 4	-	1	2	1	1	3	3	2	1	1	1	2	-	-	-
CO 5	-	1	2	-	-	2	2	2	1	2	2	2	-	-	-
Average	**1**	**1.5**	**2.6**	**1**	**1**	**2.2**	**2.4**	**2**	**1**	**1.25**	**1.2**	**2**	**-**	**1**	**-**

GE23217 தமிழரும் தொழில்நுட்பமும் L T P C
1 0 0 1

அலகு I நெசவு மற்றும் பானைத் தொழில்நுட்பம்: 3

சங்க காலத்தில் நெசவுத் தொழில் - பானைத் தொழில்நுட்பம் - கருப்பு சிவப்பு பாண்டங்கள் - பண்டங்களில் கீறல் குறியீடுகள்.

அலகு II வடிவமைப்பு மற்றும் கட்டிடத் தொழில்நுட்பம்: 3

சங்க காலத்தில் வடிவமைப்பு மற்றும் கட்டுமானங்கள் & சங்க காலத்தில் வீட்டுப்பொருட்களில் வடிவமைப்பு - சங்க காலத்தில் கட்டுமான பொருட்களும் நடுகல்லும் - சிலப்பதிகாரத்தில் மேடை அமைப்பு பற்றிய விவரங்கள் - மாமல்லபுரச் சிற்பங்களும், கோவில்களும் - சோழர் காலத்துப் பெருங்கோயில்கள் மற்றும் பிற வழிபாட்டுத் தலங்கள் - நாயக்கர் காலக் கோயில்கள் - மாதிரி கட்டமைப்புகள் பற்றி அறிதல், மதுரை மீனாட்சி அம்மன் ஆலயம் மற்றும் திருமலை நாயக்கர் மஹால் - செட்டிநாடு வீடுகள் - பிரிட்டிஷ் காலத்தில் சென்னையில் இந்தோ - சாரோசெனிக் கட்டிடக் கலை.

அலகு III உற்பத்தித் தொழில் நுட்பம்: 3

கப்பல் கட்டும் கலை - உலோகவியல் - இரும்புத் தொழிற்சாலை - இரும்பை உருக்குதல், எஃகு - வரலாற்றுச் சான்றுகளாக செம்பு மற்றும் தங்க நாணயங்கள் - நாணயங்கள் அச்சடித்தல் - மணி உருவாக்கும் தொழிற்சாலைகள் - கல்மணிகள், கண்ணாடி மணிகள் - சுடுமண் மணிகள் - சங்கு மணிகள் - எலும்புத்துண்டுகள் - தொல்லியல் சான்றுகள் - சிலப்பதிகாரத்தில் மணிகளின் வகைகள்.

அலகு IV வேளாண்மை மற்றும் நீர்ப்பாசனத் தொழில் நுட்பம்: 3

அணை, ஏரி, குளங்கள், மதகு - சோழர்காலக் குமுழித் தூம்பின் முக்கியத்துவம் - கால்நடை பராமரிப்பு - கல்நடைகளுக்காக வடிவமைக்கப்பட்ட கிணறுகள் - வேளாண்மை மற்றும் வேளாண்மைச் சார்ந்த செயல்பாடுகள் - கடல்சார் அறிவு - மீன்வளம் - முத்து மற்றும் முத்துக்குளித்தல் - பெருங்கடல் குறித்த பண்டைய அறிவு - அறிவுசார் சமூகம்.

அலகு V அறிவியல் தமிழ் மற்றும் கணித்தமிழ் : 3

அறிவியல் தமிழின் வளர்ச்சி - கணித்தமிழ் வளர்ச்சி - தமிழ் நூல்களை மின்பதிப்பு செய்தல் - தமிழ் மென்பொருட்கள் உருவாக்கம் - தமிழ் இணையக் கல்விக்கழகம் - தமிழ் மின் நூலகம் - இணையத்தில் தமிழ் அகராதிகள் - சொற்குவைத் திட்டம்.

TOTAL : 15 PERIODS

TEXT-CUM-REFERENCE BOOKS

1. தமிழக வரலாறு - மக்களும் பண்பாடும் - கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்).
2. கணினித் தமிழ் - 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.

SEMESTER III

Course Code	Course Title	Category	L	T	P	C
MA23312	FOURIER SERIES AND NUMBER THEORY	BS	3	1	0	4

Common to III Sem. B.E. – Electrical and Electronics Engineering, Electronics and Communication Engineering, Biomedical Engineering, Computer Science and Engineering & Computer Science and Engineering (Cyber Security)
and
B.Tech. – Information Technology

Objectives:

- To express Fourier series to study the behaviour of periodic functions and their applications in system communications, digital signal processing and field theory.
- To represent continuous function arising in wave and heat propagation, signals and systems using Fourier Transforms
- To provide various numerical methods in solving problems that occurs in the field of Engineering and Technology.
- To introduce and apply the concepts of finite fields and congruences.
- To present a rigorous development of Number Theory using axioms, definitions, examples, theorems and their proofs.

UNIT-I	**FOURIER SERIES**	12

Dirichlet's conditions – General Fourier series – Odd and even functions – Half range sine series – Half range cosine series –Parseval's identity – Harmonic analysis.

UNIT-II	**FOURIER TRANSFORMS**	12

Statement of Fourier integral theorem – Fourier transform pair – Fourier sine and cosine transforms – Properties – Transforms of simple functions – Convolution theorem – Parseval's identity - Application to boundary value problems.

UNIT-III	**NUMERICAL SOLUTIONS OF BOUNDARY VALUE PROBLEMS**	12

Finite difference method for solving second order differential equations - Finite difference techniques for the solution of two-dimensional Laplace and Poisson equations on rectangular domain – One dimensional heat flow equation by implicit and explicit methods – One Dimensional Wave Equation by Explicit method

UNIT-IV	**CONGRUENCES**	12

Finite Fields -Linear Diophantine equations – Congruence's – Linear Congruence's – Applications: Divisibility tests – Modular exponentiation-Chinese remainder theorem – 2 x 2 linear systems.

UNIT-V	**CLASSICAL THEOREMS IN NUMBER THEORY**	12

Wilson's theorem – Fermat's little theorem – Euler's theorem – Euler's Phi functions – Tau and Sigma functions.

Total Contact Hours:60

Course Outcomes:

On completion of the course, students will be able to

- Demonstrate Fourier series to study the behaviour of periodic functions and their applications in engineering problems such as system communications, digital signal processing and field theory.
- Apply the shifting theorems, Fourier integral theorems, Inverse Fourier sine and cosine transforms appropriate problems in engineering and technology.
- Solve differential equations numerically that arise in course of solving complex engineering problems.
- Explain the fundamental concepts of finite fields and congruence, and their role in modern mathematics and applied contexts.
- Work effectively as part of a group to solve challenging problems in Number Theory.

SUGGESTED ACTIVITIES

- Problem solving sessions
- Tutorial Sessions by involving two faculty members

SUGGESTED EVALUATION METHODS

- Problem solving in Tutorial sessions

- Assignment problems
- Quizzes and class test
- Discussion in classroom

Reference Books / Web links:	
1	Erwin Kreyszig, "Advanced Engineering Mathematics", 10th Edition, Wiley India, 2015.
2	Veerarajan. T., "Transforms and Partial Differential Equations", Tata McGraw Hill Education Pvt.Ltd.,New Delhi, Second reprint, 2016.
3	Grimaldi, R.P and Ramana, B.V., "Discrete and Combinatorial Mathematics", Pearson Education, 5th Edition, New Delhi, 2007.
4	Koshy, T., "Elementary Number Theory with Applications", Elsevier Publications, New Delhi, 2002.
5	Grewal B.S., "Higher Engineering Mathematics", 43rd Edition, Khanna Publishers, Delhi, 2014.
Reference Books / Web links:	
1	Ramana B.V., "Higher Engineering Mathematics", Tata McGraw Hill Publishing Company Limited, New Delhi, 2017.
2	Glyn James, "Advanced Modern Engineering Mathematics", 4th Edition, Pearson Education, 2016
3	GrewalB.S., and Grewal. J.S., "Numerical Methods in Engineering and Science", 11th Edition, Khanna Publishers, New Delhi, 2013.
4	Lidl, R. and Pitz, G, "Applied Abstract Algebra", Springer Verlag, New Delhi, 2nd Edition, 2006.
5	Niven, I., Zuckerman.H.S., and Montgomery, H.L., "An Introduction to Theory of Numbers", John Wiley and Sons , Singapore, 2004.

COs/POs&PSOs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO 1	3	3	3	2	1	-	-	-	-	-	-	1	2	1	2
CO 2	3	3	3	2	1	-	-	-	-	-	-	1	2	1	2
CO 3	3	3	3	2	2	-	-	-	-	-	1	2	1	2	2
CO 4	3	3	3	2	2	-	-	-	-	-	1	2	1	2	2
CO 5	3	3	3	3	2	-	-	-	-	-	-	2	1	2	2
Average	**3**	**3**	**3**	**2.2**	**1.6**	**-**	**-**	**-**	**-**	**-**	**1**	**1.6**	**1.4**	**1.6**	**2**

Course Code	**Course Title(Theory Course)**	**Category**	**L**	**T**	**P**	**C**
EE23311	**ELECTROMAGNETIC THEORY**	**ES**	**3**	**0**	**0**	**3**

Objectives:

- To teach the basic concepts of electrostatics.
- To impart knowledge on applications of electrostatics.
- To provide knowledge on magnetic materials and the laws of magnetostatics
- To derive the Maxwell's equations for electromagnetic fields.
- To teach the computation of the electromagnetic wave parameters.

UNIT-I	**INTRODUCTION TO ELECTROSTATICS**	**9**

Scalars and Vectors, Unit Vector, Position and distance vector, sources of electromagnetic field, coordinate systems- Del, Gradient, Divergence, Curl- theorems- Coulomb's law- Electric field due to discrete and continuous charges distribution – Electric flux density-Gauss's law.

UNIT-II	**APPLICATIONS OF ELECTROSTATICS**	**9**

Electric potential - Relationship between E and V- Electric Dipole-Equipotential-Energy density- Electric field in free space, conductors, Dielectric- Polarization- dielectric strength-continuity equation - Boundary conditions- Capacitance- Poisson's and Laplace's equations- Applications.

UNIT-III	**MAGNETOSTATICS**	**9**

Biot Savart's Law – Ampere's Circuit Law- H due to straight conductors, circular loop, solenoid, infinite sheet of current, infinitely long coaxial transmission line- Magnetic flux density- forces due to magnetic field-Magnetic Torque-Magnetization-Magnetic Materials - Boundary conditions - Inductance of coaxial cable and transmission lines – Magnetic Energy – Applications.		
UNIT-IV	**ELECTRODYNAMIC FIELDS**	**9**
Magnetic Circuits – Faraday's law- Transformer and motional EMF- Displacement current, Conduction current, Convection current- Maxwell's equation (differential and integral form) – Maxwell's equation in phasor form (differential and integral form)- Relation between field and circuit theories – Applications- Introduction to finite element analysis.		
UNIT-V	**ELECTROMAGNETIC WAVES**	**9**
Waves equation in general- Wave parameters; velocity, intrinsic impedance, propagation constant- Wave propagation in lossy dielectric, lossless dielectric, free space, good conductor- skin depth-power and the Poynting vector-Applications.		
	Total Contact Hours : 45	

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

●	comprehend the basic laws of electrostatics.
●	determine the field quantities based on laws of electrostatics.
●	analyze the field quantities based on the laws of magnetostatics.
●	obtain Maxwell's equations for electromagnetic fields.
●	evaluate the electromagnetic wave parameters.

SUGGESTED ACTIVITIES:

1. Activity Based Learning.
2. Implementation of small module

SUGGESTED EVALUATION METHODS:

1. Assignment problems
2. Class Presentation/Discussion

Text Book (s):

1	Mathew N. O. Sadiku and S.V.Kulkarni, "Principles of Electromagnetics", 6th Edition, Oxford University Press Inc. Asian edition, 2015.
2	Ashutosh Pramanik, "Electromagnetism – Theory and Applications", PHI Learning Private Limited, New Delhi, Second Edition-2009.
3	K.A. Gangadhar, P.M. Ramanathan, "Electromagnetic Field Theory (including Antennas and wave propagation', 16th Edition, Khanna Publications, 2023.

Reference Books(s) :

1	W.H. Hayt ,J. A. Buck and M Jaleel Akhtar, "Engineering Electromagnetics", McGraw-Hill, 9th Edition-2020
2	Joseph A. Edminister, Electromagnetics, Schaum's Outline Series, Tata McGrawHill, Revised 2nd Edition-2017
3	John Kraus and Daniel Fleisch, Electromagnetics with Applications, McGraw-Hill, 5thedition- 2017
4	David K. Cheng ,Fundamentals of Engineering Electromagnetics, Pearson Education India- 2014
5	Bhag Singh Guru and Hüseyin R. Hiziroglu "Electromagnetic field theory Fundamentals", Cambridge University Press; Second Revised Edition, 2009.

Web links:

1	https://onlinecourses.nptel.ac.in/noc21_ee83/preview
2	https://ieeexplore.ieee.org/book/7362911

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	-	-	-	-	-	-	-	-	-	-	3	1	3
CO 2	3	3	-	1	2	-	-	-	-	-	-	-	3	1	3
CO 3	3	3	-	1	2	-	-	-	-	-	-	-	3	1	3
CO 4	3	3	-	1	2	-	-	-	-	-	-	-	3	1	3
CO 5	3	3	-	1	1	-	-	-	-	-	-	-	3	1	3

Average	**3**	**3**	**-**	**1**	**1.75**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**3**	**1**	**3**

Course Code	**Course Title(Theory Course)**	**Category**	**L**	**T**	**P**	**C**
EE23312	**ELECTRICAL MACHINES – I**	**PC**	**3**	**0**	**0**	**3**

Objectives:

- To impart knowledge on the principle of operation, construction and working of DC Generators
- To teach the characteristics of DC Motors of different types, their starting and speed control methods.
- To familiarize the construction two winding and autotransformers and their principle of operations, Equivalent circuit and calculation of Regulation.
- To provide knowledge on testing of DC machines and transformers to evaluate their performance.
- To give exposure on the deign aspects of single-phase and three-phase transformers.

UNIT-I	**DC GENERATORS**	**9**

Constructional details – EMF equation – Methods of excitation – Self and separately excited generators – Characteristics of series, shunt and compound generators – fundamentals of armature reaction.

UNIT-II	**DC MOTORS**	**9**

Principles of electromechanical energy conversion - DC Motor operation – Back emf and torque equation – Series, Shunt and Compound motors – Characteristics – applications- Starting methods – Speed control.

UNIT-III	**TRANSFORMERS**	**9**

Constructional details of core and shell type transformers – Types of windings – Principle of operation – EMF equation –Parameters referred to HV / LV windings – Equivalent circuit – Transformer on load – Regulation – Parallel operation of single-phase transformers – Auto transformers – Three phase transformers – Tap changing.

UNIT-IV	**TESTING OF DC MACHINES AND TRANSFORMERS**	**9**

Losses and efficiency in DC machines – Condition for maximum efficiency – Testing of DC machines – Brake test, Swinburne's test and Hopkinson's test – Testing of transformers – evaluation of losses, Polarity test, load test – Sumpner's test- All day efficiency.

UNIT-V	**DESIGN OF TRANSFORMERS**	**9**

output equation of single phase and three phase transformers – design of core, yoke and windings for core and shell type transformers — design of tank and cooling of transformers.

Total Contact Hours	**:**	**45**

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

- Comprehend the construction and functioning of different types of DC Generators
- Realize the need for different types of DC motors, based on their applications and speed control methods.
- Apply the transformer of appropriate rating for any given application, after calculating its performance
- Evaluate the losses and efficiency of DC machines and Transformers by various testing methods.
- Estimate the main dimensions of the single and three-phase transformers for given ratings, from output equations.

Suggested Activities:

1. Exposure through industrial visit
2. Group discussion on applications
3. Giving Tutorial sessions

Suggested Evaluation Methods:

1. Seminars
2. Group assignment

Text Book (s):

1	D.P. Kothari and I.J. Nagrath, "Electric Machines", Tata McGraw Hill Publishing Company Ltd, 4th edition, 2017
2	B. L. Theraja and AK Theraja, "A Text book of Electrical Technology", Volume 2, S. Chand Publications, 2015.
3	A.K. Sawhney, ―A Course in Electrical Machine Design, DhanpatRai and Sons, New Delhi, 1984.

Reference Books(s) :

1	P.S. Bimbhra, "Electrical Machinery", Khanna Publishers, Fully revised Edition ,2021.

2	A.E. Fitzgerald, Charles Kingsley, Stephen.D.Umans, "Electric Machinery", Tata McGraw Hill publishing Company Ltd, 6th edition, 2003.
3	J.B. Gupta, "Theory and Performance of Electrical Machines", S.K.Kataria and Sons, 2009.
4	R.K. Agarwal, ―Principles of Electrical Machine Design, S.K.Kataria and Sons, Delhi, 2002.
5	Theodore Wildi, "Electrical Machines, Drives and Power Systems", Sixth Edition, Pearson Publishers, 2013
Web links :	
1	https://www.youtube.com/watch?v=97G6FGS2JC0

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	3	3	-	2	-	3	-	2	3	3	1	3
CO 2	3	3	3	3	3	-	2	-	3	-	2	3	3	1	3
CO 3	3	3	3	3	3	-	2	-	3	-	2	3	3	1	3
CO 4	3	3	3	3	3	-	2	-	3	-	2	3	3	1	3
CO 5	3	3	3	3	3	-	2	-	3	-	2	3	3	1	3
Average	**3**	**3**	**3**	**3**	**3**	-	**2**	-	**3**	-	**2**	**3**	**3**	**1**	**3**

Course Code	**Course Title(Theory Course)**	**Category**	**L**	**T**	**P**	**C**
EE23313	**MEASUREMENTS AND INSTRUMENTATION**	**PC**	**3**	**0**	**0**	**3**

Objectives:

- To teach the functional elements, characteristics and types of errors in instrumentation system.
- To impart knowledge on various electrical instruments.
- To provide knowledge on various electronic instruments and display devices.
- To teach the different methods of measurement of R, L and C using bridges.
- To provide knowledge on various sensors, transducers and data acquisition systems.

UNIT-I **INTRODUCTION** **9**

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

UNIT-II **ELECTRICAL INSTRUMENTS** **9**

Permanent Magnet Moving Coil and Moving Iron Meters – Dynamometer type Wattmeter and Induction type Energy Meter (Single phase and three phase) - Dynamometer type Power Factor Meter – Introduction to Instrument Transformers (Construction and working) – Power measurement using Instrument Transformers- Introduction to Power Quality Analyser.

UNIT-III **ELECTRONIC INSTRUMENTS AND DISPLAY DEVICES** **9**

Introduction to Electronic Voltmeter – Digital Voltmeter – Multimeter – Digital Frequency meter – Digital Phase meter – CRO –Digital Storage Oscilloscope - LED, LCD and Dot Matrix Display – Data Loggers

UNIT-IV **DC AND AC BRIDGES** **9**

DC and AC Potentiometers – Measurement of low and medium resistance using DC bridges (Wheatstone and Kelvin's double bridge) – Measurement of inductance and capacitance using AC bridges (Maxwell's and Schering's bridge) – Electrostatic and Electromagnetic interference – Shielding - Grounding techniques.

UNIT-V **SENSORS AND TRANSDUCERS** **9**

Basics of Sensors and Transducers-Classification of Transducers – Selection of transducers – Resistive, Capacitive and Inductive transducers – Hall sensor, Interfacing Hall effect current sensor with microcontroller, Flux measurement using Hall sensor, Proximity Sensors – Introduction to digital encoder, Interfacing Rotary Encoder with ADC of microcontroller- Gyro Sensor, Flow Sensor- Data Acquisition System

Total Contact Hours : 45

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

- comprehend the basic concepts of measurements and instrumentation.
- analyze the working of various electrical instruments.
- analyze the working of various electronic instruments and display devices.

•	realize the different methods of measurement of resistance, inductance and capacitance using Bridges.
•	analyze the different types of sensors and transducers.
SUGGESTED ACTIVITIES • Seminar Presentation	
SUGGESTED EVALUATION METHODS • Mini Project	
Text book(s)	
1	A.K. Sawhney, "A Course in Electrical & Electronic Measurements & Instrumentation", Dhanpat Rai and Co, 2021.
2	J. B. Gupta, "A Course in Electronic and Electrical Measurements", S. K. Kataria & Sons, Delhi, 2013.
3	E. O. Doebelin and D. N. Manik, "Measurement Systems – Application and Design", Tata McGraw-Hill, New Delhi, 6th Edition 2017
Reference Books(s) / Web links:	
1	H.S. Kalsi, "Electronic Instrumentation and Measurements", Tata McGraw Hill, 4th Edition 2019.
2	R. K. Rajput, "Electrical and Electronics Measurements and Instrumentation", Chand Publishers, 2016
3	R.B. Northrop, 'Introduction to Instrumentation and Measurements', Taylor & Francis, New Delhi, 3rd Edition 2014.
4	Martin Reissland, "Electrical Measurements", New Age International (P) Ltd., Delhi, 2001.
5	Alan. S.Morris, "Principles of Measurements and Instrumentation", 2nd Edition, Prentice Hall of India, 2006.
6	Helfrick and Cooper, "Modern Electronic Instrumentation and Measurement Techniques", Prentice-Hall of India, Reprint 1988
7	Golding, E.W., "Electrical Measurement and Measuring Instruments", 3rd Edition, Sir Isaac Pitman and Sons, 1960

COs/POs&PSOs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO 1	3	3	3	3		2	2		1	1	2	3	3	1	3
CO 2	3	3	3	1		2	2	2	1	1	2	3	3	2	3
CO 3	3	3	3	3		2	2		1	1	2	3	3	2	3
CO 4	3	3	3	1		2	2	2	1	1	2	3	3	1	3
CO 5	3	3	3	3	2	1	1		3	1	3	3	3	1	3
Average	**3**	**3**	**3**	**2.2**	**2**	**1.8**	**1.8**	**2**	**1.4**	**1**	**2.2**	**3**	**3**	**1.4**	**3**

Course Code	**Course Title(Theory Course)**	**Category**	**L**	**T**	**P**	**C**
EE23314	**ELECTRONIC DEVICES AND CIRCUITS**	**PC**	**3**	**0**	**0**	**3**

Objectives:

●	To teach the structure and operation of basic electronic devices.
●	To provide knowledge on the operation and characteristics of various transistors
●	To inculcate the concepts of small signal modeling of amplifiers.
●	To impart knowledge on several multistage and feedback amplifiers.
●	To familiarize the concepts of different types of oscillators and multivibrator circuits.

UNIT-I	**PN JUNCTION DIODES**	**9**

PN junction diode – structure, operation and V-I characteristics – Diode packages - Rectifiers – Half Wave and Full Wave Rectifier – Clipping & Clamping circuits – Photo diode – Zener diode characteristics – Zener as regulator- Introduction to SiC and GaN Devices

UNIT-II	**TRANSISTORS**	**9**

BJT, JFET, MOSFET – structure, operation, characteristics - Transistor packages - UJT – Structure, characteristics. UJT as saw tooth oscillator- Photo transistor.

UNIT-III	**AMPLIFIERS**	**9**

BJT amplifier circuit- Load line and Operating point analysis – Analysis of CE, CB, CC amplifiers using h-parameters – Gain and frequency response –JFET and MOSFET amplifier circuit – Small signal analysis of CS and Source follower – Gain and Frequency response.		
UNIT-IV	**MULTISTAGE AND FEEDBACK AMPLIFIERS**	**9**
Differential amplifier – Common mode and Differential mode analysis using BJT. Power amplifiers – Class A, Class B, Class C, Class AB and Class E . Advantages of negative feedback – voltage /current, series, shunt feedback.		
UNIT-V	**OSCILLATORS AND MULTIVIBRATORS**	**9**
Positive feedback – Condition for oscillations, phase shift – Wien bridge, Hartley and Colpitts Crystal oscillators. Non-sinusoidal oscillators – Multivibrators – Bi-stable, Monostable, Astable Multivibrators.		
	Total Contact Hours : 45	

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

●	comprehend the structure of the basic electronic devices.
●	realize the characteristics of various transistors
●	analyze and obtain small signal model of all types of amplifiers.
●	design multistage and feedback amplifier circuits.
●	realize the working principles of various oscillators and multivibrators.

SUGGESTED ACTIVITIES

- Mini project using Electronic devices can be carried out.
- Quiz can be conducted to know real time application of Electronic devices.

SUGGESTED EVALUATION METHODS

- Mini project can be considered.

Text Book (s):

1	David A. Bell, "Electronic Devices and Circuits", Prentice Hall of India, 5th edition, 2008.
2	Sedra and smith, "Microelectronic Circuits", Oxford University Press, 8th edition, 2020.
3	R.S.Sedha, "A Textbook of Electronic Circuits" S.Chand Publications, 2014

Reference Books(s) / Web links:

1	Rashid, "Microelectronic Circuits" Analysis and design: Cengage learning,3rd edition 2017.
2	S.Salivahanan, "Electronic Devices and Circuits", Tata McGraw Hill Education, 4th edition 2017.
3	Floyd, "Electron Devices" Pearson Asia, 10th edition, 2017.
4	Donald A Neamen, "Electronic Circuit Analysis and Design" Tata McGraw Hill, 3rd edition, 2007.
5	Robert L.Boylestad, "Electronic Devices and Circuit theory", Pearson Prentice Hall, 11th edition, 2015.
6	Robert B. Northrop, "Analysis and Application of Analog Electronic Circuits to Biomedical Instrumentation", CRC Press, 2017.

Web links for virtual lab (if any)

1	https://www.youtube.com/watch?v=n0SiQIaitHk
2	https://www.youtube.com/watch?v=sRVvUkK0U80
3.	https://www.youtube.com/watch?v= KXldjWyYXI&t=3s

COs/POs&PSOs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO 1	3	2	1	1	2	2	1	1	2	1	2	3	3	1	2
CO 2	3	2	1	1	2	2	1	1	2	1	2	3	3	1	2
CO 3	3	3	3	3	2	2	1	1	2	1	2	3	3	1	2
CO 4	3	3	3	3	2	2	1	1	2	1	2	3	3	1	2
CO 5	3	3	3	3	2	2	1	1	2	1	2	3	3	1	2
Average	**3**	**2.6**	**2.2**	**2.2**	**2**	**2**	**1**	**1**	**2**	**1**	**2**	**3**	**3**	**1**	**2**

Course Code	**Course Title(Theory Course)**	**Category**	**L**	**T**	**P**	**C**
EE23315	**POWER PLANT ENGINEERING**	**PC**	**3**	**0**	**0**	**3**

Objectives:

•	To provide knowledge on the operation of hydro and thermal power plant and its subsystems

•	To teach the basic components of the energy conversion in nuclear power plants.	
•	To familiarize the layout and operation of Renewable energy power plants	
•	To educate the environmental impact and operating cost of various power plants	
•	To introduce the importance of instrumentation, measurement and control techniques in power plants.	
UNIT-I	**HYDRO AND THERMAL POWER PLANTS**	**9**
Hydro Electric Power Plants – Classification, Typical Layout and associated components including Turbines. -Rankine cycle – Layout of modern coal power plant, Supercritical Boilers, FBC Boilers, Turbines, Condensers, Steam & Heat rate, Subsystems of thermal power plants – Fuel and ash handling, Draught system, Feed water treatment. Binary Cycles and Cogeneration systems.		
UNIT-II	**NUCLEAR POWER PLANTS**	**9**
Introduction, General Components of Nuclear Reactor, General Problems of Reactor Operation, Different Types of Reactors, Pressurised Water Reactors (PWR), Boiling Water Reactors (BWR), Heavy Water – cooled and Moderated CANDU (Canadian Deuterium Uranium) Types of Reactors, Gas-cooled Reactors, Breeder Reactors, Nuclear Power Station in India, Safety measures for Nuclear Power plants.		
UNIT-III	**RENEWABLE ENERGY SOURCES**	**9**
Principle, Construction and working of Wind, Tidal, Solar, Solar Thermal, Geo Thermal, Biogas and Fuel Cell power systems.		
UNIT-IV	**ENERGY, ECONOMIC AND ENVIRONMENTAL ISSUES OF POWER PLANTS**	**9**
Power tariff types, Load distribution parameters, Comparison of site selection criteria, Capital & Operating Cost of different power plants (Cost Analysis). Pollution control Technologies including Waste Disposal Options for Coal and Nuclear Power plants.		
UNIT-V	**POWER PLANT INSTRUMENTATION AND CONTROL**	**9**
Plant Automation, Plant Optimization, Safety & Protection, Importance of measurement and instrumentation in power plant, measurement of water purity, gas analysis, O_2 and CO_2 measurements, measurement of smoke, dust and moisture.		
	Total Contact Hours : 45	
Course Outcomes: On completion of the course, the students will be able to		
•	analyze the working mechanism of coal based thermal power plants.	
•	comprehend the components of nuclear power plants	
•	realise the working principles of components utilized in Renewable energy power plants.	
•	realize the environmental and economic issues in power plants.	
•	determine the various parameters associated with power plant instrumentation	
Suggested Activities: • Industrial visits can be arranged for the students to understand more about various operations of power generating plants		
Suggested Evaluation Methods: ● Class Presentation/Discussion		
Text Book (s):		
1	P. K. Nag, Power Plant Engineering, McGraw-Hill Publishing Company Ltd., Fifth Edition, 2021.	
2	M.M. El-Wakil, "Power Plant Technology", Tata McGraw – Hill Publishing Company Ltd., First Edition, 2017.	
Reference Books(s) :		
1	Thomas C. Elliott, Kao Chen and Robert C. Swanekamp, "Standard Handbook of Power Plant Engineering", McGraw – Hill Publisher, Second Edition, 1997	
2	Godfrey Boyle, Renewable energy, Oxford University Press in association with the Open University, Third Edition, 2012.	
3	Black & Veatch, "Power Plant Engineering", Springer Publisher, 1996.	
4	ElWakil , "Power Plant Technology", McGraw Hill Education; 1st Edition,2017	
5	Krishnaswamy.K and Ponnibala.M., "Power Plant Instrumentation", PHI Learning Pvt.Ltd. Second Edition 2014.	
Web links :		
www.iienet.org		

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	2	2	-	1	1	1	-	-	1	-	2	2	3	3
CO 2	3	2	3	2	2	2	2	-	-	1	-	3	2	3	3
CO 3	3	2	2	-	1	2	1	-	-	1	-	3	2	3	3
CO 4	3	2	2	3	1	1	2	-	-	1	-	3	2	3	3
CO 5	3	2	2	-	1	2	3	-	-	1	-	3	3	3	3
Average	**3**	**2**	**2.2**	**2.5**	**1.2**	**1.6**	**1.8**	**-**	**-**	**1**	**-**	**2.8**	**2.2**	**3**	**3**

Course Code	Course Title(Laboratory Course)	Category	L	T	P	C
EE23321	**ELECTRONIC DEVICES AND CIRCUITS LABORATORY**	**PC**	**0**	**0**	**2**	**1**

Objectives:

- To experimentally verify the characteristics of semiconductor devices.
- To realize the applications of semiconductor devices.
- To design and study the amplifier and oscillator circuits.
- To study the frequency response of amplifier circuits.
- To obtain the characteristics of astable multivibrator.

List of Experiments

1	Characteristics of Semiconductor diode and Zener diode.
2	Wave generation using Clipper & Clamper circuits.
3.	Single Phase half-wave and full wave rectifiers with inductive and capacitive filters
4.	Characteristics of photodiode and phototransistor.
5.	Characteristics of a NPN Transistor under common emitter, common collector and common base configurations.
6	Characteristics of JFET and UJT.
7	Design and Frequency response characteristics of a Common Emitter amplifier
8	Design and testing of RC phase shift oscillator.
9	Design and testing of LC oscillator.
10	Astable Multivibrator

Total Contact Hours : 30

Course Outcomes:

On completion of the course, students will be able to

- experimentally analyze the characteristics of various semiconductor devices.
- realize the applications of semiconductor devices.
- design and evaluate the performance parameters of amplifier and oscillator circuits.
- obtain the frequency response of BJT amplifier.
- realize the characteristics of astable multivibrator.

Lab Equipment Required

S.No.	Name of the Equipment	Quantity required
1.	Regulated Power Supply	12 Nos.
2.	Dual Trace CRO (20 MHz)	12 Nos.
3.	Function Generator	12 Nos.
4.	Digital Multimeter	10 Nos.
5.	Bread Boards	40 Nos.
6.	Transistor	25 Nos.
7.	JFET	10 Nos.

8.	Diode	10 Nos.
9.	Zener Diode	5 Nos.
10.	UJT	5 Nos.
11.	Photo Diode/ Photo Transistor Kit	5 Nos.
12.	DC Ammeter (0-100mA)	15 Nos.
13.	DC Ammeter (0-50μA)	10 Nos.
14.	DC Voltmeter (0-30V)	10 Nos.
15.	Resistors of various ranges	50 Nos.
16.	Capacitors of various ranges	50 Nos.
17.	Connecting wires	Sufficient Nos

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	-	3	2	1	2	-	-	3	3	3	3	3	1	1
CO 2	3	3	3	2	1	2	-	-	3	3	3	3	3	1	1
CO 3	3	3	3	2	1	2	-	-	3	3	3	3	3	1	1
CO 4	3	3	3	2	1	2	-	-	3	3	3	3	3	1	1
CO 5	3	3	3	2	1	2	-	-	3	3	3	3	3	1	1
Average	**3**	**3**	**3**	**2**	**1**	**2**	**-**	**-**	**3**	**3**	**3**	**3**	**3**	**1**	**1**

Course Code	Subject Name(Laboratory Course)	Category	L	T	P	C
GE23231	**PROGRAMMING USING PYTHON** Common to all branches of B. E. / B.Tech program (Except–CSE, CSBS, CSD, IT, AI/ML, CYBER SECURITY, AI/DS)	**ES**	**1**	**0**	**4**	**3**

Course Objectives:

- To understand computers, programming languages and their generations and essential skills for a logical thinking for problem solving.
- To write, test, and debug simple Python programs with conditionals, and loops and functions
- To develop Python programs with defining functions and calling them
- To understand and write python programs with compound data-lists, tuples, dictionaries
- To search, sort, read and write data from /to files in Python.

List of Experiments

1.	Study of algorithms, flowcharts and pseudocodes.
2.	Introduction to Python Programming and Python IDLE/Anaconda distribution.
3.	Experiments based on Variables, Data types and Operators in Python.
4.	Coding Standards and Formatting Output.
5.	Algorithmic Approach: Selection control structures.
6.	Algorithmic Approach: Iteration control structures.
7.	Experiments based on Strings and its operations.
8.	Experiments based on Lists and its operations.
9.	Experiments based on Tuples and its operations.
10.	Experiments based on Sets and its operations.
11.	Experiments based on Dictionary and its operations.
12.	Functions: Built-in functions.
13.	Functions: User-defined functions.
14.	Functions: Recursive functions.
15.	Searching techniques: Linear and Binary.
16.	Sorting techniques: Bubble and Merge Sort.
17.	Experiments based on files and its operations.

Contact Hours : 75

Course Outcomes:

On completion of the course, students will be able to:

- understand the working principle of a computer and identify the purpose of a computer programming language and ability to identify an appropriate approach to solve the problem.
- write, test, and debug simple Python programs with conditionals and loops.

•	develop Python programs step - wise by defining functions and calling them.
•	use Python lists, tuples, dictionaries for representing compound data.
•	apply searching, sorting on data and efficiently handle data using flat files.
TextBooks:	
1.	Allen B. Downey, Think Python:How to Think Like a Computer Scientist, Second edition,UpdatedforPython3, Shroff/ O'Reilly Publishers, 2016 (http://greenteapress.com/wp/think-python/)
2.	Guido Van Rossum and Fred L. Drake Jr, An Introduction to Python-Revised and updated for Python3.2, Network Theory Ltd., 2011.
ReferenceBooks:	
1.	JohnVGuttag, Introduction to Computation and Programming Using Python, Revised and expanded Edition, MIT Press,2013.
2.	Robert Sedgewick, Kevin Wayne, Robert Dondero, Introduction to Programming in Python: An Inter-disciplinary Approach, Pearson India Education Services Pvt.Ltd., 2016.
3.	Timothy A.Budd, Exploring Python, Mc-Graw Hill Education(India)PrivateLtd.,2015.
4.	Kenneth A. Lambert, Fundamentals of Python: First Programs, CengageLearning,2012.
5.	Charles Dierbach, Introduction to Computer Science using Python: A Computational Problem Solving Focus, Wiley India Edition,2013.
6.	Paul Gries, Jennifer Campbell and Jason Montojo, Practical Programming: An Introduction to Computer Science using Python3, Second edition, Pragmatic Programmers, LLC, 2013.

Platform Needed: Python3 interpreter for Windows/Linux

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	2	2	2	2	1	-	-	-	1	1	1	1	1	1	2
CO 2	2	1	1	1	1	-	-	-	-	-	1	1	1	1	2
CO 3	1	1	2	1	2	-	-	-	-	-	1	1	1	1	2
CO 4	2	2	3	2	2	-	-	-	-	-	2	1	1	1	2
CO 5	2	2	3	2	3	-	-	-	-	-	2	1	1	1	2
Average	**1.8**	**1.6**	**2.2**	**1.6**	**1.8**	-	-	-	**1**	**1**	**1.4**	**1**	**1**	**1**	**2**

SEMESTER IV

Course Code	Course Title(Theory Course)	Category	L	T	P	C
EE23411	ELECTRICAL MACHINES – II	PC	3	0	0	3

Objectives:

●	To provide knowledge on construction, theory of operation and performance of synchronous generators.
●	To teach the operation, starting methods and current Loci of synchronous motors.
●	To explain the details of the construction, principle of operation and performance of three phase and single-phase induction motors.
●	To provide exposure on the starting and speed control of three phase and single-phase induction motors
●	To teach the details of specific loadings and the design fundamentals of three-phase Induction motors.

UNIT-I	SYNCHRONOUS GENERATORS	9

Constructional details – Types of rotors – EMF equation – Synchronous reactance – Armature reaction – Voltage regulation – EMF, MMF, and ZPF methods , Synchronizing and parallel operation – Synchronizing torque - Change of excitation and mechanical input – Two reaction theory – Determination of direct and quadrature axis synchronous reactance of salient pole machines by Slip test.

UNIT-II	SYNCHRONOUS MOTORS	9

Principle of operation – Torque equation – Operation on infinite bus bars - V-curves – Power input and power developed equations – Starting methods – Current loci for constant power input, constant excitation and constant power developed – Hunting - Damper Windings.

UNIT-III	INDUCTION MOTORS	9

Constructional details – Types of rotors – Principle of operation – Slip – Equivalent circuit – Slip-torque characteristics - Condition for maximum torque -No load and blocked rotor tests- Load test – Losses and efficiency –Circle diagram – Separation of no-load losses — Induction generators – Self-excited and Grid connected.- Single-phase induction motors: Double revolving field theory – Equivalent circuit – No load and blocked rotor tests – Performance analysis.

UNIT-IV	STARTING AND SPEED CONTROL OF INDUCTION MOTORS	9

Need for starting – Types of starters for three phase induction motors – autotransformer, star-delta and rotor resistance starters – Methods of speed control – Change of voltage, frequency - number of poles – Slip power recovery scheme. Starting methods of single-phase induction motors – Universal motor

UNIT-V	DESIGN OF THREE-PHASE INDUCTION MOTORS	9

Output equation – choice of specific electric and magnetic loadings – main dimensions – design of stator – winding design for given poles - design of squirrel cage and slip ring rotors. Introduction to computer aided design of induction motors.

Total Contact Hours	:	45

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

●	Understand the theory of synchronous generators and the calculation of the regulation of non- salient pole and salient pole alternators by various methods.
●	Describe the complete operation of synchronous motors including its starting methods.
●	Comprehend the various features of three phase and single-phase induction motors, starting from their principle of operation.
●	Choose the appropriate method of starting of three-phase and single-phase induction motors.
●	Calculate the main dimensions of three-phase induction motors, for the given ratings.

SUGGESTED ACTIVITIES

1. Exposure through industrial visit

2. Group discussion on applications

3. Giving Tutorial sessions

SUGGESTED EVALUATION METHODS

1. Seminars

2. Group assignment

Text Book (s):

1	D.P. Kothari and I.J. Nagrath, "Electric Machines", Tata McGraw Hill Publishing Company Ltd, 4th edition, 2010
2	B. L. Theraja and AK Theraja, "A Text book of Electrical Technology", Volume 2, S. Chand Publications, 2015.

3	A.K. Sawhney, ―A Course in Electrical Machine Design, DhanpatRai and Sons, New Delhi, 1984.
Reference Books(s) :	
1	P.S. Bimbhra, "Electrical Machinery", Khanna Publishers, 7th edition, 2003.
2	A.E. Fitzgerald, Charles Kingsley, Stephen.D.Umans, "Electric Machinery", Tata McGraw Hill publishing Company Ltd, 6th edition, 2003.
3	J.B. Gupta, "Theory and Performance of Electrical Machines", S.K.Kataria and Sons, 2009.
4	R.K. Agarwal, ―Principles of Electrical Machine Design, S.K.Kataria and Sons, Delhi, 2002.
5	Theodore Wildi, "Electrical Machines, Drives and Power Systems", Sixth Edition, Pearson Publishers, 2013
Web links :	
1	https://www.youtube.com/watch?v=97G6FGS2JC0

COs/POs&PSOs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO 1	3	3	3	3	3	1	2	-	3	1	2	3	3	2	3
CO 2	3	3	3	3	3	1	2	-	3	1	2	3	3	2	3
CO 3	3	3	3	3	3	1	2	-	3	1	2	3	3	2	3
CO 4	3	3	3	3	3	1	2	-	3	1	2	3	3	2	3
CO 5	3	3	3	3	3	1	2	-	3	1	2	3	3	2	3
Average	**3**	**3**	**3**	**3**	**3**	**1**	**2**	**-**	**3**	**1**	**2**	**3**	**3**	**2**	**3**

Course Code	**Course Title(Theory Course)**	**Category**	**L**	**T**	**P**	**C**
EE23412	**TRANSMISSION AND DISTRIBUTION**	**PC**	**3**	**0**	**0**	**3**

Objectives:

- To impart knowledge on the structure of electric power system and various distribution schemes.
- To provide knowledge on the computation of transmission line parameters.
- To impart knowledge on the modelling of transmission lines and determination of voltage regulation and efficiency.
- To familiarize the voltage distribution in insulator strings and cables.
- To inculcate knowledge on the mechanical design of transmission line, sag calculations and substation layout.

UNIT-I	**STRUCTURE OF POWER SYSTEM**	**9**

Structure of electric power system: generation, transmission and distribution; Types of AC and DC distributors – distributed and concentrated loads – interconnection – Introduction to EHVAC, HVDC transmission, FACTS and Smart Grid.

UNIT-II	**TRANSMISSION LINE PARAMETERS**	**9**

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 – interference with neighbouring communication circuits – corona discharges.

UNIT-III	**MODELLING AND PERFORMANCE OF TRANSMISSION LINES**	**9**

Classification of lines – short line, medium line and long line – equivalent circuits, phasor diagram, attenuation constant, phase constant, surge impedance; transmission efficiency and voltage regulation. Real and reactive power flow in lines, surge impedance loading, Ferranti effect, Transmission line loss reduction using FACTS device.

UNIT-IV	**INSULATORS AND CABLES**	**9**

Insulators: Types of insulator, voltage distribution in insulator string, improvement of string efficiency. Underground cables: Types of cables, Capacitance of single core cable, Grading of cables, Heating of cables, Capacitance of three core cables.

UNIT-V	**MECHANICAL DESIGN OF LINES**	**9**

Mechanical design of transmission line – sag and tension calculations for different weather conditions, Tower spotting, Types of towers, Substation Layout (AIS, GIS) – Busbar arrangements.

		Total Contact Hours	**:**	**45**

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

●	comprehend the structure of electric power system, distribution schemes, HVDC system and FACTS devices.
●	evaluate the transmission line parameters.
●	determine the voltage regulation and efficiency of the transmission lines.
●	analyze the voltage distribution in insulator strings and cables
●	realize the mechanical design of transmission line, sag calculations and substation layout.

SUGGESTED ACTIVITIES

- Industrial visit can be arranged for students to know more about practical implementation of substation layout.
- Mini Project (Modeling of Power System Network)

SUGGESTED EVALUATION METHODS

- Evaluation can be done from the project on simulation of modelling of power system network.

1	D.P.Kothari, I.J. Nagrath, "Power System Engineering", Tata McGraw-Hill Publishing Company limited, New Delhi, Fifth Edition, 2022.
2	C.L.Wadhwa, "Electrical Power Systems", New Academic Science Ltd, Sixth Edition, 2018.
3	S.N. Singh, "Electric Power Generation, Transmission and Distribution", Prentice Hall of India Pvt. Ltd, New Delhi, Second Edition, 2011.

Reference Books(s) :

1	B.R.Gupta, S.Chand, "Power System Analysis and Design" New Delhi, Sixth Edition, 2011.
2	Luces M.Faulkenberry ,Walter Coffer, "Electrical Power Distribution and Transmission", Pearson Education, 2007.
3	Hadi Saadat, "Power System Analysis", PSA Publishing; Third Edition, 2010.
4	J.Brian, Hardy and Colin R.Bayliss, "Transmission and Distribution in Electrical Engineering", Newnes; Fourth Edition, 2012.
5	Kankar Bhattacharya, Jaap E. Daadler, Math H.J. Boolen, "Operation of restructured power systems", Kluwer Academic Pub., 2001.
6	Stuart Borlase, "Smart Grid :Infrastructure, Technology and Solutions", CRC Press 2017.

Web links :

1	https://npp.gov.in/dashBoard/trans-map-dashboard
2	https://cea.nic.in/wp-content/uploads/2020/04/765_powerplants.pdf

COs/POs&PSOs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO 1	3	3	3	3	3	2	2	-	2	1	3	3	3	3	3
CO 2	3	3	3	3	3	2	2	-	2	1	3	3	3	3	3
CO 3	3	3	3	3	3	2	2	-	2	1	3	3	3	3	3
CO 4	3	3	3	3	3	2	2	-	2	1	3	3	3	3	3
CO 5	3	3	3	3	3	2	2	-	2	1	3	3	3	3	3
Average	**3**	**3**	**3**	**3**	**3**	**2**	**2**	**-**	**2**	**1**	**3**	**3**	**3**	**3**	**3**

Course Code	**Course Title(Laboratory Integrated Theory Course)**	**Category**	**L**	**T**	**P**	**C**
EE23431	**DIGITAL LOGIC CIRCUITS**	**PC**	**3**	**0**	**2**	**4**

Objectives:

●	To impart knowledge on various number systems and to simplify logical expressions using Boolean laws.
●	To inculcate the concepts of design and implementation of combinational logic circuits.
●	To design synchronous logic circuits, FSMs and introduce ASMs
●	To analyze asynchronous sequential circuits and study Programmable Logic Devices.
●	To familiarize Hardware descriptive language(HDL) for the implementation of combinational circuits and simple FSMs

UNIT-I	**NUMBER SYSTEMS AND LOGIC FUNCTIONS**	**9**
Number systems - Binary Codes – Error detection and correction codes (Parity and Hamming code) - Boolean laws – Representation and implementation of logic functions - SOP and POS forms, canonical forms		
UNIT-II	**COMBINATIONAL LOGIC CIRCUITS**	**9**
Minimizing Boolean functions using K maps - Implementation of logic functions using gates - Combinational logic - adders, subtractors, Code converters - Decoder and Encoder - De-multiplexer and Multiplexer.		
UNIT-III	**SYNCHRONOUS SEQUENTIAL LOGIC CIRCUITS**	**9**
Sequential logic- SR, JK, D and T flip flops – level and edge triggering – counters – synchronous and asynchronous type – Modulo counters – Shift registers – design of synchronous sequential circuits – Moore and Mealy models - Counters, state diagram, state reduction, state assignment - FSM, ASM.		
UNIT-IV	**ASYNCHRONOUS SEQUENTIAL LOGIC CIRCUITS AND PLDs**	**9**
Analysis of asynchronous sequential logic circuits - Transition table, flow table – Races free state assignment - Hazards - Introduction to Programmable Logic Devices: PROM, PLA, PAL, FPGA - Comparison of characteristics of RTL, DTL, TTL, ECL and MOS digital logic families.		
UNIT-V	**HARDWARE DESCRIPTIVE LANGUAGE**	**9**
Register Transfer Level design – Operators of VHDL - Combinational logic, Sequential logic circuits using VHDL coding – Test bench.		
	Contact Hours : 45	

List of Experiments	
1	Study of basic digital ICs.
2	Implementation of Boolean function using logic gates. (for e.g. Adder and Subtractor)
3	Design and implementation of Code converters.(for e.g. Binary to Gray, Gray to Binary, BCD to Seven segment display using dedicated ICs)
4	Study of Encoders and Decoders, multiplexers and demultiplexers using dedicated ICs
5	Counters: Design and implementation of 4-bit modulo counters as Synchronous and Asynchronous types using FF ICs and specific counter IC.
6	Design and implementation of 4-bit shift registers in SISO, SIPO, PIPO modes using suitable IC's.

	Contact Hours	**:**	**30**
	Total Contact Hours	**:**	**75**

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

- simplify the logical expressions using reduction techniques
- design and implement combinational circuits using basic gates(basic digital ICs).
- design and implement various synchronous circuits.
- analyze and implement asynchronous sequential circuits and design combinational functions using PLDs.
- simulate HDL programs for digital logic circuits.

Suggested Activities

- A simple project on building a digital circuit for any given logic can be implemented.

Suggested Evaluation Methods

- CAT III Evaluation can be based on the presentation of the project by individual student.

Text Book (s):

1	M. Morris Mano and Michael D. Ciletti, "Digital Design with an introduction to VHDL", Pearson Education, 8th edition, 2013.
2	Thomas L Floyd, 'Digital fundamentals', Pearson Education Limited, 11th Edition, 2018.
3	William Keitz, "Digital Electronics-A Practical Approach with VHDL", Pearson, 2013.

Reference Books(s) :

1	Charles H.Roth, Jr. Lizy Kurian John, "Digital System Design using VHDL", Cengage, 3 rd edition, 2017
2	John M.Yarbrough, "Digital Logic, Application & Design", Thomson, 2002
3	Botros, "HDL Programming Fundamentals, VHDL & Verilog", Cengage, 2013.
4	Anand Kumar, "Fundamentals of Digital Circuits", PHI, 2013
5	Gaganpreet Kaur, "VHDL Basics to Programming", Pearson, 2013.

Web links :

1	https://onlinecourses.nptel.ac.in/noc23_ee29/preview

2	https://www.academia.edu/45565761/Digital_design_morris_mano_fifth_edition

Lab Equipments Required

	Name of the Equipment	Quantity Required	Remarks
1	Digital IC trainer kit	15	-
2	Digital IC tester	2	-
3	Digital multimeter	2	-
4	Necessary Digital ICs for logic gates like AND , OR, NOT, NAND, NOR, EXOR and dedicated ICs for Decoder Encoder, MUX, DEMUX and Counters	30 each	ICs like IC7400, IC7402, IC7404, IC7408, IC7432, IC7486, IC7447, IC74138, IC74139, IC74153, IC74155, IC7490, IC7473, IC7474 can be procured.
5	Single stand wires and Wire strippers	Sufficient quantity	-

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	2	-	-	-	-	3	3	2	3	3	-	2
CO 2	3	3	3	2	2	1	-	-	3	3	2	3	3	-	3
CO 3	3	3	3	2	2	1	-	-	3	3	2	3	3	-	3
CO 4	3	3	3	2	-	1	-	-	3	3	2	3	3	-	3
CO 5	3	3	2	2	2	1	-	-	3	3	2	3	3	-	3
Average	**3**	**3**	**3**	**2**	**2**	**1**	**-**	**-**	**3**	**3**	**2**	**3**	**3**	**-**	**2.8**

Course Code	**Course Title(Laboratory Integrated Theory Course)**	**Category**	**L**	**T**	**P**	**C**
EE23432	**LINEAR INTEGRATED CIRCUITS AND APPLICATIONS**	**PC**	**3**	**0**	**2**	**4**

Objectives:

- To teach the IC fabrication procedure and the internal structure of an op-amp.
- To provide knowledge on the characteristics, design and implementation of basic op-amp applications.
- To explore active filters, signal generators, ADC and DAC.
- To impart knowledge on design and implementation of IC 555 timer, VCO and PLL.
- To inculcate knowledge on design of power supply using regulator ICs.

UNIT-I **OP-AMP FUNDAMENTALS AND CHARACTERISTICS** **9**

Fundamentals of monolithic IC technology and fabrication – Internal structure of op-amp – Ideal op-amp characteristics - Inverting and Non-inverting Amplifiers – DC characteristics, AC characteristics (Frequency response, Stability and slew rate)

UNIT-II **BASIC APPLICATIONS OF OP-AMP** **9**

Voltage follower – Summing amplifier – Differential amplifier –V/I and I/V converter – Differentiator – Integrator – Instrumentation amplifier–Log and Antilog amplifier–S/H circuit.

UNIT-III **APPLICATIONS OF OP-AMP** **9**

First and Second order low and high pass active filters – Comparators – Multivibrators – Triangular wave generators – – Digital to Analog converter (R - 2R ladder and weighted resistor types) – Analog to Digital converters (Successive approximation and Flash type).

UNIT-IV **SPECIAL ICs** **9**

Functional block, characteristics and application circuits with IC555 Timer – IC566 Voltage Controlled Oscillator (VCO) – IC 565 Phase Locked Loop (PLL) – Applications of PLL (frequency multiplier and frequency divider)

UNIT-V **REGULATOR ICs** **9**

IC voltage regulators – LM78XX, 79XX – Fixed voltage regulators – LM317, 723, Variable voltage regulators, switching regulator – SMPS

Contact Hours : 45

List of Experiments				
1	Applications of Op-amp (Amplifier, Adder and Subtractor)			
2	Op- Amp based Differentiator and Integrator			
3	Design and development of first and second order active filters.			
4	Design and development of Astable and Monostable Multivibrator using 555 timer IC			
5	Design and development of fixed and variable power supplies using LM7805, LM 7905 and LM317 IC			
6	Design and development of frequency multiplier and divider using PLL IC.			
7	Design and development of SMPS using LM78S40 IC			
		Contact Hours	**:**	**30**
		Total Contact Hours	**:**	**75**
Course Outcomes: On completion of course, students will be able to				
•	obtain the characteristics of an op-amp			
•	realize the various mathematical applications of op-amp.			
•	design the active filters using op-amp.			
•	generate a PWM pulses using 555 timer.			
•	develop power supply circuits.			
SUGGESTED ACTIVITIES • Mini Projects using IC 741 and 555 timer. • Technical quiz on integrated circuits.				
SUGGESTED EVALUATION METHODS • Continuous Assessment Test • Assignments • Viva-Voce				
Text book(s)				
1	D. Roy Choudhary, Sheilb.Jani, "Linear Integrated Circuits", sixth edition, New Age, 2022.			
2	Ramakant A.Gayakwad, "Op-amps and Linear Integrated Circuits", fourth edition, Pearson Education, 2015.			
3	Sergio Franco, "Design with Operational Amplifiers and Analog Integrated Circuits", 4th Edition, Tata Mc Graw-Hill, 2016			
Reference Books(s) / Web links:				
1	S.Salivahanan & V.S. Kanchana Bhaskaran, "Linear Integrated Circuits", TMH,2nd Edition, 4th Reprint, 2016			
2	B. Visvesvara Rao , "Linear Integrated circuits", Pearson education , 2015.			
3	Robert F.Coughlin, Fredrick F. Driscoll, "Op-amp and Linear ICs", PHI Learning, 6th edition, 2012.			

Lab Equipment Required

S.No	Name of Equipments	No. of quantity required
1	Function Generator	7
2	DSO	7
3	IC741	30
4	555 timer IC	15
5	LM7805, LM7905, LM317 IC	Each 10 Quantities
6	Transformer 230/12 V, 1A	7
7	Bread board	7
8	Single strand wire and wire stripper	1 coil and 3 Quantities

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	2	3	-	1	1	2	-	3	3	3	1	2

CO 2	3	3	3	3	3	-	1	1	2	-	3	3	3	1	2
CO 3	3	3	3	3	3	-	1	1	2	-	3	3	3	1	2
CO 4	3	3	3	3	3	-	1	1	2	-	3	3	3	1	2
CO 5	3	3	3	3	3	-	1	1	2	-	3	3	3	1	2
Average	**3**	**3**	**3**	**2.8**	**3**	**-**	**1**	**1**	**2**	**-**	**3**	**3**	**3**	**1**	**2**

Subject Code	Subject Name	Category	L	T	P	C
OE23***	**OPEN ELECTIVE-I**	**OE**	**3**	**0**	**0**	**3**

Course Code	Course Title(Laboratory Course)	Category	L	T	P	C
EE23421	**ELECTRICAL MACHINES LABORATORY**	**PC**	**0**	**0**	**4**	**2**

Objectives:

●	To impart knowledge on experimenting with DC machines and finding their characteristics
●	To teach the methods of testing transformers and arriving at their performance
●	To provide the procedures for determining the regulation three-phase alternators
●	To familiarize the techniques of experimenting with three-phase and single-phase induction motors
●	To introduce the usage of simulation tool to analyze the performance of Induction Machines.

List of Experiments

1	Load test on DC shunt and Series motor
2	Speed control of DC shunt motor.
3	Open circuit and short circuit tests on single phase transformer.
4	Load test on single-phase transformer
5	Regulation of three phase alternator by EMF and MMF methods.
6	V and Inverted V curves of Three Phase Synchronous Motor
7	Equivalent circuit and performance predetermination of three-phase induction motor.
8	Load test on three-phase induction motors.
9	Equivalent circuit and performance predetermination of single-phase induction motor.
10	Simulation of three-phase induction machines.
	Total Contact Hours : 60

SUGGESTED ACTIVITIES

1. Demonstration of synchronization of alternators

2. Showing the comparison of staring methods of three-phase induction motors.

SUGGESTED EVALUATION METHODS

1. Conducting Viva-Voce
2. Giving suitable simulation assignments on machine performance

Course Outcomes:

On completion of the course, students will be able to

●	Apply the experimental procedures to evaluate the characteristics of DC machines.
●	Conduct tests and become familiar with the determination of the performance of transformers, being widely applied machines.
●	Arrive at the correct regulation values of three-phase alternators experimentally, since the predetermination methods are not accurate.
●	Test methodically and evaluate the performance of three-phase and single-phase induction motors, being most commonly used motors.
●	Assess the characteristics of three-phase induction machines by Simulation methods.

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	3	3	-	2	-	3	-	2	3	3	-	3

CO 2	3	3	3	3	3	-	2	-	3	-	2	3	3	-	3
CO 3	3	3	3	3	3	-	2	-	3	-	2	3	3	-	3
CO 4	3	3	3	3	3	-	2	-	3	-	2	3	3	-	3
CO 5	3	3	3	3	3	-	2	-	3	-	2	3	3	2	3
Average	**3**	**3**	**3**	**3**	**3**	**-**	**2**	**-**	**3**	**-**	**2**	**3**	**3**	**2**	**3**

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**C**
GE23421	**SOFT SKILLS-I**	**EEC**	**0**	**0**	**2**	**1**

Objectives:

- To help the students break out of shyness.
- To build confidence
- To enhance English communication skills.
- To encourage students' creative thinking to help them frame their own opinions.

Learning and Teaching Strategy:

The program is completely student centric where the focus is on activities led by students which include role plays, discussions, debates other games as well. These activities would be supplemented by interactive use of technology and brief trainer input.

Week	**Activity Name**	**Description**	**Objective**
1	Introduction	The trainer and the college facilitator talk to the students about the course and in turn the students introduce themselves.	To set expectations about the course and the students are made aware of the rules and regulations involved in this program
2	If I ruled the world	This is a quick and useful game by getting students to form a circle and provide their point of view. Each student then repeats what the other has said and comes up with their own opinion.	The aim of this activity is to for students to get to know each other and also develop their listening skills as well as learning how to agree and disagree politely.
3	Picture Narrating	This activity is based on several sequential pictures. Students are asked to tell the story taking place in the sequential pictures by paying attention to the criteria provided by the teacher as a rubric. Rubrics can include the vocabulary or structures they need to use while narrating.	The aim of this activity is to make the students develop creative way of thinking.
4	Brainstorming	On a given topic, students can produce ideas in a limited time. Depending on the context, either individual or group brainstorming is effective and learners generate ideas quickly and freely. The good characteristics of brainstorming are that the students are not criticized for their ideas so students will be open to sharing new ideas.	The activity aims at making the students speak freely without the fear of being criticized. It also encourages students to come up with their own opinions.
5	Debate	Is competition necessary in regards to the learning process?	The aim of this activity is to develop the students ability to debate and think out of the box
6	Short Talks	Here the students are given topics for which they take one minute to prepare and two minutes to speak. They can write down points but can't read them out they can only use it as a reference.	The activity aims at breaking the students' shyness and encouraging them to standup in front of the class and speak. It also aims at creating awareness that they are restricted for time so they only speak points that are relevant and important.
7	Debate	Will posting students' grades on bulletin boards publicly motivate them to perform better or is it humiliating?	This activity aims at enhancing the students unbiased thought process when it comes to exams and grades

			as well as develop their skills to debate
8	The Art of diplomacy	The facilitator proceeds to share multiple concepts of conversation and helps the participants to identify the various methods of being diplomatic and how do deal with misinformation.	The aim of the lesson is to provide an opportunity for the participants to learn about body language and choosing the appropriate words for conversation.
9	Debate	Are humans too dependent on computers?	The aim of this activity is to test the students debating skills and thought process with a topic that affects everybody in daily life.
10	Story Completion	The teacher starts to tell a story but after 2 sentences he/she asks students to work in groups to create the rest of the story which includes the plot and the ending.	This activity aims at building their narrating skills as well as their creativity and ability to work in a team.
11	Role play debate	Students scrutinize different points of view or perspectives related to an issue. For example, a debate about the question "Should students be required to wear uniforms at school?" might yield a range of opinions. Those might include views expressed by a student (or perhaps two students – one representing each side of the issue), a parent, a school principal, a police officer, a teacher, the owner of a clothing store, and others.	The aim of this activity is to get students to speak based on other people's perspective instead of their own. The students take the role of various characters and debate accordingly.
12	I Couldn't Disagree More	This is a game where students practice rebuttal techniques where one student provides a thought or an idea and the other students starts with the phrase I couldn't disagree more and continues with his opinion	The aim of this activity is to improve general communication skills and confidence.
	Feedback	At the end of the session in the final week (12) the trainer would provide feedback to the students on best practices for future benefits	The aim is to do both give feedback to students as well as obtain feedback on the course from them.
		Total Contact Hours	**30**

Course Outcomes: At the end of the course the student will be able to	
●	Be more confident
●	Speak in front of a large audience
●	Be better creative thinkers
●	Be spontaneous
●	Communicate in English

COs/POs&PSOs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO 1	-	-	-	-	-	-	-	-	1	3	-	1	-	-	-
CO 2	1	-	-	-	-	-	1	-	1	3	1	1	-	-	-
CO 3	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
CO 4	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
CO 5	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
Average	**1**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**3**	**1**	**1**	**-**	**-**	**-**

Course Code	**Course Title(Laboratory Course)**	**Category**	**L**	**T**	**P**	**C**

CS23422	PYTHON PROGRAMMING FOR MACHINE LEARNING	ES	0	0	4	2

Course Objectives:

- To understand the relationship of the data collected for decision making.
- To know the concept of principal components, factor analysis and cluster analysis for profiling and interpreting the data collected.
- To lay the foundation of machine learning and its practical applications and prepare students for real-time problem-solving in data science.
- To develop self-learning algorithms using training data to classify or predict the outcome of future datasets.
- To distinguish overtraining and techniques to avoid it such as cross-validation.

List of Experiments

1. NumPy Basics: Arrays and Vectorized Computation
2. Getting Started with pandas
3. Data Loading, Storage, and File Formats
4. Data Cleaning and Preparation
5. Data Wrangling: Join, Combine, and Reshape
6. Plotting and Visualization
7. Data Aggregation and Group Operations
8. Time Series
9. Supervised Learning
10. Unsupervised Learning and Pre-processing
11. Representing Data and Engineering Features
12. Model Evaluation and Improvement

Contact Hours : 60

Course Outcomes:

On completion of the course, students will be able to

- develop a sound understanding of current, modern computational statistical approaches and their application to a variety of datasets.
- analyze and perform an evaluation of learning algorithms and model selection.
- compare the strengths and weaknesses of many popular machine learning approaches.
- appreciate the underlying mathematical relationships within and across machine learning algorithms and the paradigms of supervised and unsupervised learning.
- design and implement various machine learning algorithms in a range of real-world applications.

Text Books:

1. Wes McKinney, Python for Data Analysis - Data wrangling with Pandas, Numpy, and IPython, Second Edition, O'Reilly Media Inc, 2017.
2. Andreas C. Müller and Sarah Guido, Introduction to Machine Learning with Python - A Guide for Data Scientists, First Edition, O'Reilly Media Inc, 2016.

Reference Books:

1. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, 2nd Edition, O'Reilly Media Inc, 2019.

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	2	2	2	2	1	-	-	-	1	1	1	1	1	1	1
CO 2	2	1	1	1	1	-	-	-	-	-	1	1	1	1	1
CO 3	1	1	2	1	2	-	-	-	-	-	1	1	1	1	1
CO 4	2	2	3	2	2	-	-	-	-	-	2	1	1	1	1
CO 5	2	2	3	2	3	-	-	-	-	-	2	1	1	1	1
Average	**1.8**	**1.6**	**2.2**	**1.6**	**1.8**	**-**	**-**	**-**	**1**	**1**	**1.4**	**1**	**1**	**1**	**1**

SEMESTER V

Subject Code	Subject Name	Category	L	T	P	C
EE23511	POWER SYSTEM ANALYSIS	PC	3	0	0	3

Objectives:

- To impart knowledge on the modeling of various power system elements under steady state operating condition.
- To provide knowledge on solution of power flow problems using numerical methods.
- To inculcate the impact of balanced and unbalanced faults in power system.
- To familiarize modeling of generators, transformers, lines and cables in the positive, negative and zero sequence systems.
- To get knowledge on modeling and analysis of transient behaviour of power system when it is subjected to a fault.

UNIT-I INTRODUCTION 9

Basic Components of Power system-Need for system planning and operational studies - Power scenario in India - Power system Single line diagram - per unit representation - Network modeling of power system components – Per unit Reactance and Impedance diagram -Construction of Y-bus using inspection and singular transformation methods.

UNIT-II POWER FLOW ANALYSIS 9

Importance of power flow analysis – classification of buses - Formulation of power flow model in complex and polar coordinates - Iterative solution using Gauss-Seidel method, Newton -Raphson method – Comparison between Gauss-Seidel and Newton –Raphson load flow methods. Case Study: Load flow analysis with FACTS devices.

UNIT-III FAULT ANALYSIS – BALANCED FAULTS 9

Importance of short circuit analysis - assumptions in fault analysis - analysis using Thevenin's theorem - Z-bus matrix formation using Bus building Algorithm – Three phase fault analysis using Z-bus matrix – computations of short circuit capacity, post fault voltage and currents with no load and full loads – Current limiting reactors.

UNIT-IV FAULT ANALYSIS – UNBALANCED FAULTS 9

Introduction to symmetrical components – sequence impedances – sequence network - Analysis of unsymmetrical fault at generator terminals: single line to ground, line to line, double line to ground faults - – unsymmetrical fault occurring in any point in a power system - Case study for fault analysis: Transformer, Transmission lines.

UNIT-V STABILITY ANALYSIS 9

Importance of stability analysis in power system - classification of power system stability - Single Machine Infinite Bus (SMIB) system- Development of swing equation - Equal area criterion - Determination of critical clearing angle and time – Multi machine stability analysis - Modified Euler method.

Total Contact Hours : 45

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

- realize the nature of the modern power system, including the behaviour of the constituent Components and sub-systems and evaluate the individual parts of an electrical power system.
- analyze load flow of an electrical power network and interpret the results of the analysis.
- analyze a network under both balanced and unbalanced fault conditions and interpret the results
- comprehend modeling of generators, transformers, lines and cables in the positive, negative and zero sequence systems.
- evaluate the transient stability of a single machine infinite bus system using both analytical and time simulation methods.

Suggested Activities

- Tutorial sessions
- Exposure through industrial visit

Suggested Evaluation Methods

- Seminars
- Group Assignments

Text Book(s):

1. Nagrath I.J., Kothari D.P. and Saket R.K., 'Modern Power System Analysis', Tata McGraw-Hill, Fifth Edition, 2022.
2. John J. Grainger and W.D. Stevenson Jr., 'Power System Analysis', Tata McGraw-Hill, Sixth reprint, 2017.

Reference Books(s):

1. HadiSaadat, 'Power System Analysis', Tata McGraw Hill Education Pvt. Ltd., New Delhi, 21st reprint, 2010.
2. Kundur P. and Malik P., 'Power System Stability and Control, Tata McGraw Hill Education Pvt. Ltd., New Delhi, Second Edition, 2022.
3. J. Duncan Glover, Thomas J. Overbye and Mulukutla S. Sarma, , ' Power System Analysis & Design',Cengage Learning, Sixth Edition, 2017.
4. P. Venkatesh, B.V. Manikandan, S. Charles Raja, A. Srinivasan, 'Electrical Power Systems- Analysis, Security and Deregulation', PHI Learning Private Limited, New Delhi, 2012.

Web links :

	https://archive.nptel.ac.in/courses/108/104/108104051/
	https://archive.nptel.ac.in/courses/108/105/108105067/

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	2	2		1					2	3	3	2
CO 2	3	3	3	2	2		1					2	3	3	2
CO 3	3	3	3	2	2		1					2	3	3	2
CO 4	3	3	3	2	2		1					2	3	3	2
CO 5	3	3	3	2	2		1					2	3	3	2
Average	**3**	**3**	**3**	**2**	**2**		**1**					**2**	**3**	**3**	**2**

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**C**
EE23512	**POWER ELECTRONICS**	**PC**	**3**	**0**	**0**	**3**

Objectives:

- To impart knowledge on the different types of power semiconductor devices and their switching characteristics.
- To inculcate the operation, characteristics and performance parameters of controlled rectifiers.
- To study the operation, switching techniques and basics topologies of DC-DC switching regulators.
- To learn the different modulation techniques and harmonics suppression for pulse width modulated inverters.
- To get knowledge on the operation of AC voltage controller and various configurations

UNIT-I	**POWER SEMI-CONDUCTOR SWITCHES AND CIRCUITS**	9

Study of switching devices, Power Transistors, SCR, TRIAC, MOSFET, IGBT- Temperature dependent Static and Dynamic characteristics - Triggering and commutation circuit for SCR- Design of Driver and snubber circuit- Introduction to Intelligent Power module (IPM).Introduction SiC Devices.

UNIT-II	**AC TO DC CONVERTERS**	9

2-pulse, 3-pulse and 6-pulseconverters using R and RL loads– Performance parameters –Effect of source inductance– Dual converters, Light dimmer and static excitation applications

UNIT-III	**DC TO DC CONVERTERS**	9

Non isolated converters-Buck, Boost and Buck Boost- switched mode power supply- Isolated Converters- Push pull, Fly back converter-Introduction to Resonant converters- Battery operated vehicle –mobile charger

UNIT-IV	**DC TO AC CONVERTERS**	9

Voltage Source Inverter-Current Source Inverter-PWM Techniques – Diode Clamped Multi level Inverter- Induction Heating and RF lighting

UNIT-V	**AC TO AC CONVERTERS**	9

AC Voltage Controllers - Integral cycle control – Multistage sequence control-single phase step up and step down cyclo converter and three phase Cyclo converter- Welding application

	Total Contact Hours	**: 45**

Course Outcomes:

On completion of course, students will be able to

- Realize a power electronic converters with proper choice of semiconductor devices
- Evaluate the performance parameters of a controlled rectifier system.
- Obtain an efficient SMPS.
- Analyse and Design the inverters based on harmonic suppression.
- Evaluate the AC to AC converter system.

Text Book (s):

1	M.H.Rashid, "Power Electronics: Circuits, Devices and Applications", Pearson Education, PHI 4th Edition, New Delhi, 2017.
2	P.S.Bimbra "Power Electronics", Khanna Publishers, 6th Edition, 2018.
3	L. Umanand, "Power Electronics Essentials and Applications", Wiley, 2009.

Reference Books(s) / Web links:	
1	Joseph Vithayathil,"Power Electronics, Principles and Applications", McGraw Hill Series, 6thReprint, 2013.
2	Ashfaq Ahmed, "Power Electronics for Technology", Pearson Education, Indian reprint, 2003.
3	Philip T. Krein, "Elements of Power Electronics" Oxford University Press, 2012 Edition.
4	Ned Mohan, Tore. M. Undel and, William. P. Robbins, "Power Electronics: Converters, Applications and Design", John Wiley and sons, 3rd edition, 2007.
5	Daniel.W.Hart, "Power Electronics", Indian Edition, McGraw Hill Education, 2nd edition, 2013.
6	M.D. Singh and K.B. Khanchandani, "Power Electronics," McGraw Hill India, 2017.
7	S. Rama Reddy, "Fundamentals of Power Electronics', Narosa,2014 Edition
8	Course material on "Switched Mode Power Conversion" by V.Ramanarayanan

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	1	1			2	2		1		1	2	2	1	1
CO 2	2	3	3	1		2	2		1		1	2	3	2	3
CO 3	2	3	3	1		2	2		1		1	2	3	2	3
CO 4	2	3	3	1		2	2		1		1	2	3	2	3
CO 5	2	3	3	1		2	2		1		1	2	3	2	3
Average	**2.2**	**2.6**	**2.6**	**0.8**		**2**	**2**		**1**		**1**	**2**	**2.8**	**1.8**	**2.6**

Subject Code	Subject Name	Category	L	T	P	C
EE23513	**CONTROL SYSTEMS**	**PC**	**3**	**0**	**0**	**3**

Objectives:

- To get familiarized with various representations of systems.
- To teach the time response of linear systems for various inputs.
- To inculcate knowledge on obtaining the open loop and closed–loop frequency responses of systems.
- To explore the stability of linear systems in time domain and frequency domain.
- To learn the importance of compensator and design of different kinds of compensators.

UNIT-I	**SYSTEMS AND THEIR REPRESENTATION**	9

Basic elements in control systems – Open and closed loop systems – Transfer function –mathematical model of mechanical and electrical system – AC and DC servomotors, Synchros- Electrical analogy of mechanical system– Block diagram reduction techniques – Signal flow graphs.

UNIT-II	**TIME RESPONSE**	9

Types of test signal –Time response of I and II order system – Time domain specifications-Steady state error – Error coefficients – Generalized error series – Effects of P, PI, PD, PID modes of feedback control – Modeling and Design of Electronic P, PI and PID controller-Use of software tools to analyze and design of control system.

UNIT-III	**FREQUENCY RESPONSE**	9

Frequency response – frequency domain specifications Correlation between frequency domain and time domain specifications – Bode plot - Polar plot– Gain margin and phase margin.

UNIT-IV	**STABILITY ANALYSIS**	9

Stability analysis, characteristic equation, location of roots in s plane for stability, effect of addition of pole and zero, Routh-Hurwitz stability criterion – Nyquist stability criterion – root locus

UNIT-V	**COMPENSATOR DESIGN**	9

Need of compensator, types of compensator – Lag, lead and lag-lead networks – compensator design using bode plots

	Total Contact Hours :	**45**

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

- apply mathematical modeling on physical systems.

●	evaluate the transient and steady state response of the system.
●	draw and analyze the frequency response of the system by using bode plots and polar plots.
●	determine the stability analysis by using Routh Hurwitz criterion, Nyquist stability criterion, root locus and also verified with MATLAB simulation
●	realize a Lag/Lead compensator using bode plots.
Suggested Activities Problem solving tutorial sessions Competitions	
Suggested Evaluation Methods Assignments Assessments	
Text Book (s):	
1	I.J. Nagarath and M.Gopal, "Control Systems Engineering", 7th Edition, New Age International Publishers, 2021.
2	K. Ogata, "Modern Control Engineering", 5th Edition, Pearson Education Inc., 2017.
3	M. Gopal, "Control Systems, Principles and Design", 4th Edition, Tata McGraw Hill, New Delhi, 2015
Reference Book(s):	
1	S.K.Bhattacharya, "Control Systems Engineering", 3rd Edition, Pearson Education India., 2013.
2	R. Anandanatrajan , P. Ramesh Babu, "Control Systems Engineering", Scitech Publications (India) Pvt Ltd 2018.
3	Richard C. Dorf and Robert H. Bishop, "Modern Control Systems", 12th Edition, Pearson Prentice Hall,
4	S.Palani, "Automatic Control Systems with MATLAB", 2nd Edition, Springer International Publishing,
Web links	
1	Online course material: NPTEL Course on Control Systems by Prof. C.S.Shankar Ram, IIT Madras, Web link: https://onlinecourses.nptel.ac.in/noc20_ee90.
2	Online course material: NPTEL Course on Control Engineering by Prof. Ramkrishna Pasumarthy, IIT Madras, Web link: https://nptel.ac.in/courses/108106098.

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	1	3	1	-	-	-	-	1	2	2	2	3
CO 2	3	3	3	1	3	2	1	-	-	-	3	2	3	2	3
CO 3	3	3	3	2	3	2	1	-	-	-	3	2	3	2	3
CO 4	3	3	3	3	3	2	1	-	-	-	3	2	3	2	3
CO 5	3	3	3	3	3	2	1	-	-	-	3	2	1	2	3
Average	**3**	**3**	**3**	**2**	**3**	**1.8**	**1**	**-**	**-**	**-**	**2.6**	**2**	**2.4**	**2**	**3**

Subject Code	Subject Name	Category	L	T	P	C
EE23P**	**PROFESSIONAL ELECTIVE-I**	**PE**	**3**	**0**	**0**	**3**

Subject Code	Subject Name (Lab Oriented Theory Course)	Category	L	T	P	C
EE23531	**MICROPROCESSORS, MICROCONTROLLERS AND APPLICATIONS**	**PC**	**3**	**0**	**2**	**4**

Objectives:
● To learn the architecture and programming of the 8085 microprocessor.
● To explore skills in interfacing of peripheral devices with 8085 microprocessor.
● To impact knowledge in architecture and programming of 8051 microcontroller.

- To get familiarized with interfacing of peripheral devices with 8051 microprocessor.
- To provide basic knowledge in architecture and programming of PIC 16F877 microcontroller.

Suggested activities:

Students can use online simulation tools for any applications.

Evaluation Methods:

In model practical examination, each student should be assigned to develop code for any application.

UNIT-I	**8085 MICROPROCESSOR**	**12**

Hardware Architecture, pin-diagram – Memory Interfacing Techniques - Interrupt Structure -Instruction -format and its types - Addressing modes.

UNIT-II	**PERIPHERAL INTERFACING USING 8085**	**9**

Architecture, configuration and interfacing, with ICs: 8255, 8254, 8257, 8251, A/D and D/A converters & Interfacing with 8085.

UNIT-III	**8051 MICROCONTROLLER**	**9**

Hardware Architecture, pinouts – Functional Building Blocks of Processor – Memory organization - SFR– I/O ports, Timers/Counters – Interrupts

UNIT-IV	**8051 INSTRUCTION SET AND ITS APPLICATION**	**9**

Instruction set – Addressing modes – simple programs— Application: Waveform generators - Generation of Gate signals – Servo motor control – Washing Machine Control.

UNIT-V	**INTRODUCTION ON PIC 16F877 MICROCONTROLLER**	**6**

Architecture – Memory organization –I/O port – CCP modules – RAM & ROM Allocation – UART

	Contact Hours	**:**	**45**

List of Experiments

1	Assembly language program for Arithmetic operations in 8085 microprocessor.
2	Assembly language program for arranging arrays of ‘n’ numbers in ascending and descending order in an 8085 microprocessor.
3	Assembly language program to find the smallest and largest number in an array of ‘n’ numbers in an 8085 microprocessor.
4	Assembly language program for code conversions in 8085 microprocessor.
5	Assembly language program for Arithmetic operations in 8051 microcontroller.
6	Assembly language program for 8279 interfacing with 8085 and 8051.
7	Assembly language program for A/D and D/A interfacing with 8085 and 8051.
8	Assembly language program for Digital IO interfacing with 8085 and 8051.
9	Assembly language program for Stepper motor interfacing with 8085 and 8051.

	Contact Hours	**:**	**30**
	Total Contact Hours	**:**	**75**

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

- Describe the various blocks of the 8085 microprocessor and its instructions.
- Design the interfacing circuit with various input and output devices.
- Describe the various blocks of the 8051 microprocessor and its instructions.
- Apply the reliable system for various applications using 8051 microcontroller.
- Realize the advanced features of PIC 16F877 microcontroller.

Lab equipment required:

S.No.	Name of the Equipment	Quantity Required	Remarks
1	8085 Microprocessor programming kit.	10	With an instruction coding sheet.
2	8051 microcontroller programming kit.	10	With an instruction coding sheet.
3	8279 interfacing kit	5	-
4	A/D and D/A interfacing kit	5	-

5	Digital IO interfacing kit	5	-
6	Stepper motor interfacing kit	5	-

Text Book (s):

1	N.Senthil Kumar, M.Saravanan, S.Jeevananthan, ―Microprocessors and Microcontrollers‖, Oxford, Third edition, 2016.
2	Krishna Kant, ―Microprocessor and Microcontrollers‖, PH1 Learning private limited, New Delhi, Third Edition 2013.
3	A.Nagoorkani, ―Microprocessors and Microcontrollers‖, Tata McGraw Hill Publishing Company Ltd, 2nd Edition 2015.
4	Muhammad Ali Mazidi, Rolin D. Mckinlay, Danny Causey 'PIC Microcontroller and Embedded Systems using Assembly and C for PIC18', Pearson Education 2008.

Reference Books(s)

1	R.S. Gaonkar, _Microprocessor Architecture Programming and Application', with 8085, Wiley Eastern Ltd., New Delhi, 2013.
2	Muhammad Ali Mazidi & Janice GilliMazidi, R.D.Kinely _The 8051 Micro Controller and Embedded Systems', PHI Pearson Education, 5th Indian reprint, 2003.
3	K.M.Bhurchandi, ―Advanced Microprocessors and Pheripherals‖ Tata McGraw Hill Publishing Company Ltd, 3rd Edition 2013.
4	I Scott Mackenzie and Raphael C.W. Phan, "The Micro controller", Pearson, Fourth edition 2012.

Web links:

https://www.sim8085.com/

http://www.edsim51.com/

Subject Code	Subject Name	Category	L	T	P	C
OE23***	**OPEN ELECTIVE-II**	**OE**	**3**	**0**	**0**	**3**

Course Code	Course Title (Laboratory Course)	Category	L	T	P	C
EE23521	**Control and Instrumentation Laboratory**	**PC**	**0**	**0**	**2**	**1**

Objectives:

- To provide knowledge on first and second order systems using MATLAB
- To learn different types of P, PI, PD, PID controllers using MATLAB
- To teach stability analysis of linear systems along with design of Lag/Lead compensators
- To conduct an experiment on measurement of resistance, inductance and capacitance using DC and AC Bridge circuits
- To impart knowledge on signal converters such as ADC and DAC.

List of Experiments

1	Determination of transfer function of DC/AC servomotor
2	Digital Simulation of first and second order systems with step input under various damping conditions.
3	Digital simulation of P, PI, PD, PID controllers using MATLAB
4	Stability Analysis of Linear Systems using Bode plot along with Lag/Lead compensators using MATLAB
5	Stability Analysis of Linear Systems by Root locus technique using MATLAB
6	Measurement of Medium and Low Resistances using Kelvin's Double bridge and Wheatstone bridge.
7	Measurement of Inductance using Maxwell's bridge.
8	Measurement of Capacitance using Schering's bridge.
9	Analog to Digital Converter
10	Digital to Analog Converter

Total Contact Hours	**:**	**30**

Course Outcomes:

On completion of the course, students will be able to	
•	analyze the steady state and transient state response of first and second order systems using MATLAB simulation
•	realize the different types of P, PI, PD, PID controllers using MATLAB
•	analyze the stability of linear systems along with Lag/Lead compensators
•	determine the resistance, inductance and capacitance using DC and AC bridges.
•	realize the characteristics of ADC and DAC.

Suggested Activities

- Team of 3 students

Suggested Evaluation Methods

- Observation- 5, Attendace-5, Viva-5, Record-5, Model exam-30, End semester-50

Course Code	Course Title	Category	L	T	P	C
GE23627	DESIGN THINKING AND INNOVATION	EEC	0	0	4	2

Objectives:

- To understand the design thinking concepts and deep understanding of user needs and experiences.
- To find the problem statement and to develop innovative design solutions that address identified user challenges
- To master the process of prototyping and iterating on designs
- To conduct thorough market analysis and financial planning
- To effectively communicate design concepts and findings.

UNIT I	INTRODUCTION TO DESIGN THINKING	12

The design thinking concepts - Different design thinking models - Details of Stanford Design thinking process: Empathize, Define, Ideate, Prototype, Test.

Activities:

- Case studies of successful domain-based Design Thinking and Innovative projects
- Group discussions on design thinking.

UNIT II	EMPATHIZE AND DEFINE	12

User research methods (interviews, surveys, observation, contextual inquiry) - Persona development- Journey mapping – Brainstorming Defining the design problem statement.

Activities:

- Conducting user interviews and surveys
- Creating user personas and journey maps
- Identifying key user needs and pain points
- Analyze the user needs and brainstorming to define problem statement.

UNIT-III	IDEATE AND CREATE	12

Brainstorming techniques (e.g., mind mapping, SCAMPER) - Ideation tools (e.g., design thinking tools, concept sketching) - Concept generation and evaluation (e.g. Brainstorming).

Activities:

- Group brainstorming sessions to select the best idea
- Creating concept sketches and prototypes
- Evaluating ideas based on user needs and feasibility.

UNIT IV	PROTOTYPE AND TEST	12

Low, Medium and high-level fidelity for Prototyping-Usability testing -Iterative design.

Activities:

- Building low-fidelity prototypes (e.g., paper prototypes)
- Conducting usability tests with users
- Iterating on designs based on feedback.

UNIT-V	MARKET ANALYSIS AND IMPLEMENTATION	12

Market research and analysis - Business model development- Financial Planning-Implementation strategies. **Activities:** • Conducting market research • Developing a business model canvas • Creating a financial projection • Developing an implementation plan.
Total Contact Hours: 60

Course Outcomes: On completion of the course, the students will be able to
• Construct design challenge and reframe the design challenge into design opportunity.
• Interview the user, and know the feelings of users to foster deep user understanding and be able to uncover the deep user insights and needs.
• Develop ideas and prototypes by brainstorming.
• Organize the user walkthrough experience to test prototype
• Develop smart strategies and implementation plan that will deliver/achieve the idea/solution deduced from earlier phases.
Assessment: • Encourage students to work on real-world design challenges based on the user needs • Group presentations • Quizzes and exams • Evaluation of Project report and viva and also encourage the students for filing patent/ copyright / presenting in conference / publishing in journal
Text Book(s):
1. Handbook of Design Thinking by Christian Müller-Roterberg, Kindle Direct Publishing, 2018.
2. Design Thinking – A Beginner's Perspective, by E Balagurusamy, Bindu Vijakumar, MC Graw Hill, 2024.
Reference Book(s) / Web links:
1. Design Thinking for Entrepreneurs and Small Businesses: Putting the Power of Design to Work – by Beverly Rudkin Ingle, Apress; 1st Edition, 2013.
2. Design Thinking: Understanding How Designers Think and Work by Nigel Cross, Bloomsbury Visual Arts; 2nd editions 2023.
Web links:
1. Design thinking Guide https://www.rcsc.gov.bt/wp-content/uploads/2017/07/dt-guide-book-master-copy.pdf
2. NPTEL Course on Design Thinking and Innovation By Ravi Poovaiah; https://onlinecourses.swayam2.ac.in/aic23_ge17/preview
3. IITB Design course tools and Resources https://www.dsource.in/resource

PO/PSO CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
GE23627.1	3	2	3	3	3	2	2	3	3	3	3	3	3	2	2
GE23627.2	3	2	3	3	3	2	2	3	3	3	3	3	3	2	2

GE23627.3	3	2	3	3	3	2	2	3	3	3	3	3	3	2	2
GE23627.4	3	2	3	3	3	2	2	3	3	3	3	3	3	2	2
GE23627.5	3	2	3	3	3	2	2	3	3	3	3	3	3	2	2
Average	**3**	**2**	**3**	**3**	**3**	**2**	**2**	**3**	**3**	**3**	**3**	**3**	**3**	**2**	**2**

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**C**
GE23521	**SOFT SKILLS-II**	**EEC**	**0**	**0**	**2**	**1**

Objectives:

- **To help the students break out of shyness.**
- **To build confidence**
- **To enhance English communication skills.**
- **To encourage students' creative thinking to help them frame their own opinions.**

Learning and Teaching Strategy:

The program is completely student centric where the focus is on activities led by students which include role plays, discussions, debates other games as well. These activities would be supplemented by interactive use of technology and brief trainer input.

Week	**Activity Name**	**Description**	**Objective**
1	The News hour	Students are made to read news articles from the English newspapers. The students also have to find words and their meaning from the article they have not come across before and share it with the group. They then use these words in sentences of their own	The aim of this activity is not only to get the students to read the newspaper but also aims at enhancing the students' vocabulary.
2	Court Case	The facilitator provides the participants the premise of a story and proceeds to convert the story into a court case. The students are required, department-wise to debate and provide their points to win the case for their clients.	The aim of the lesson is to encourage creative and out-of-the -box thinking to ensure a good debate and defense skills.
3	The ultimate weekend	The students design activities they are going to do over the weekend and they have to invite their classmates to join in the activity. The students move around the class and talk to other students and invite them.	The aim of this activity is to develop the art of conversation among students. It also aims at practicing the grammatical structures of "going to" "have to" and asking questions.
4	The Four Corners	This is a debate game that uses four corners of the classroom to get students moving. The following is written on the 4 corners of the room "Strongly Agree, Somewhat Agree, Somewhat Disagree and Strongly Disagree". The topics are then given to the class and students move to the corner that they feel best explains their opinions	This activity aims at getting students to come up with their own opinions and stand by it instead of being overshadowed by others and forcing themselves to change based on others opinions.
5	Debate	Boarding school or day school? Which is more beneficial for a student?	The aim of this activity is to encourage students to draw up feasible points on the advantages and benefits of both. And enhance their debating ability
6	Grand Master	The facilitator starts the session by keeping an individual in mind, upon which the	The aim of the lesson is designed to teach the art of questioning. It also

		students guess it only through "Yes or No" questions. Post few trials the students are given same opportunity to do the same with the crowd.	helps to enhance the students' speaking and listening skills.
7	Debate	Does violence on the TV and Video games influence children negatively?	This activity aims at encouraging the students to debate on real life scenarios that most students spend a lot of time on.
8	Turn Tables	This is a speaking activity where the students need to speak for and against the given topics when the facilitator shouts out 'Turn Table'.	The aim of this activity is to make the participants become spontaneous and have good presence of mind.
9	Debate	*Do marks define the capabilities of a student*?	This debate activity aims at allowing the students to argue on this worrisome adage of marks.
10	FictionAD	The Participants are asked to create an Ad for a challenging topic only using fictional characters.	The activity aims at developing their creativity and presentation skills.
11	Debate	*Are social networking sites effective, or are they just a sophisticated means for stalking people?*	This activity aims at refining the students debating skills on a very real life situation
12	Talent Hunt	Talent Hunt is a fun activity where the students are selected at random and supported to present any of their own skills.	The aim of this activity is designed to evoke their inner talents and break the shyness and the fear of participating in front of a crowd
	Feedback	At the end of the session in the final week (12) the trainer would provide feedback to the students on best practices for future benefits.	The aim is to do both give feedback to students as well as obtain feedback on the course from them.
		Total Contact Hours	**30**

Course Outcomes: At the end of the course the student will be able to	
●	**Be more confident**
●	**Speak in front of a large audience without hesitation.**
●	**Be better creative thinkers**
●	**Be spontaneous**
●	**Communicate in English**

COs/POs&PSOs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO 1	-	-	-	-	-	-	-	-	2	3	1	1	-	-	-
CO 2	-	-	-	-	-	-	-	-	2	3	2	-	-	-	-
CO 3	-	1	-	-	-	-	-	-	2	3	1	1	-	-	-
CO 4	-	-	-	-	-	-	-	-	2	3	-	-	-	-	-
CO 5	-	1	-	-	-	-	-	-	2	3	1	1	-	-	-
Average	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**2**	**3**	**1.2**	**1**	**-**	-	-

SEMESTER VI

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
EE23611	PROTECTION AND SWITCHGEAR	PC	3	0	0	3

Objectives:

- To know the causes of abnormal operating conditions (faults, lightning and switching surges) of the apparatus and system.
- To learn the operation, characteristics and applications of relays and protection schemes.
- To impart knowledge on electrical apparatus protection.
- To study static and numerical relays.
- To expose on operation and function of circuit breakers.

UNIT-I	**PROTECTION SCHEMES**	9

Principles and need for protective schemes – nature and causes of faults – types of faults – fault current calculation using symmetrical components – Methods of Neutral grounding – Zones of protection and essential qualities of protection – Protection schemes

UNIT-II	**ELECTROMAGNETIC RELAYS**	9

Operating principles of relays - the 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, generator, motor, bus bars and transmission line.

UNIT-IV	**NUMERICAL PROTECTION AND DIGITAL RELAYS**	9

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

UNIT-V	**CIRCUIT BREAKERS**	9

Physics of arcing phenomenon and arc interruption- re-striking voltage and recovery voltage — rate of rise of recovery voltage -Types of circuit breakers – air blast, air break, oil, SF6 and vacuum circuit breakers – comparison of different circuit breakers – Rating and selection of circuit breakers.

Total Contact Hours	**:**	**45**	

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

- Evaluate the nature of the fault and various protection schemes.
- Know the operation of different types of electromagnetic relays.
- Apply the protection schemes for protecting the apparatus
- Realize the function of static relays.
- Know the operation of circuit breakers and the problems associated with circuit interruption by a circuit breaker.

Text Book(s):

1. Sunil S.Rao, “Switchgear and Protection”, Khanna Publishers, New Delhi, Ninth reprint, 2012.
2. B.Rabindranath and N.Chander, “Power System Protection and Switchgear”, New Age International (P) Ltd. First Edition 2011.
3. M.L.Soni, P.V.Gupta, U.S.Bhatnagar, A.Chakrabarti, “A Text Book on Power System Engineering”, DhanpatRai& Co.,2014.
4. ArunIngole , “Switchgear and Protection”,Pearson Education; First edition , May 2018)

Reference Books(s) / Web links:

1. BadriRam ,B.H. Vishwakarma, “Power System Protection and Switchgear”, New Age International Pvt Ltd Publishers, Second Edition 2011.
2. Y.G.Paithankar and S.R.Bhide, “Fundamentals of power system protection”, Second Edition,Prentice Hall of India Pvt. Ltd., New Delhi, 2010.
3. RavindraP.Singh, “Switchgear and Power System Protection”, PHI Learning Private Ltd., NewDelhi, 2009.

4	BhaveshBhalja, R.P. Maheshwari, Nilesh G. Chotani, "Protection and Switchgear" Oxford University Press, 2011.
6	P.M.Anderson" Power System Protection" Wiley-Interscience, 1999.
7	A.T.Johns and S.K.Salman" Digital protection for power system" peter peregrinus Ltd 1995.
	Web Link : https://archive.nptel.ac.in/courses/108/107/108107167/

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	2	2	2	3	2			1	2	2	3	3	2
CO 2	3	3	2	2	2	3	2			1	2	2	3	3	2
CO 3	3	3	2	2	2	3	2			1	2	2	3	3	2
CO 4	3	3	2	2	2	3	2			1	2	2	3	3	2
CO 5	3	3	2	2	2	3	2			1	2	2	3	3	2
Average	**3**	**3**	**2**	**2**	**2**	**3**	**2**			**1**	**2**	**2**	**3**	**3**	**2**

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**C**
EE23612	**SOLID STATE DRIVES**	**PC**	**3**	**0**	**0**	**3**

Objectives:

- To provide knowledge on steady state operation and transient dynamics of a motor load system.
- To teach and analyse the operation of the converter/chopper fed dc drive, both qualitatively and quantitatively.
- To expose and understand the operation and performance of induction motor drives.
- To familiarize the knowledge on using synchronous motor for drives.
- To learn the design of closed loop controlled DC drive

UNIT-I	**DRIVE CHARACTERISTICS**	9

Electric drive – Types of load- motor load dynamics – steady state stability – transient stability- multi quadrant Dynamics: acceleration, deceleration, starting & stopping – typical load torque characteristics –Selection of motor.

UNIT-II	**DC MOTOR DRIVE**	9

Transient analysis of separately excited DC motor-controlled rectifier fed DC drives-single phase and three phase-multi quadrant operation of dc separately excited motor-chopper control of separately excited and series motor-closed loop control.

UNIT-III	**INDUCTION MOTOR DRIVES**	9

Stator voltage control of induction motor–variable frequency control of IM from voltage sources and current sources-slip power recovery-Introduction to vector control. Linear Induction Motors.

UNIT-IV	**SYNCHRONOUS MOTOR DRIVES**	9

Three phase voltage/current source fed synchronous motor- V/f control and self-control of synchronous motor: Margin angle control and power factor control- Applications ~~– SRM Drives. BLDC drives.~~ Traction drives-conventional DC and AC traction drives-poly phase AC motor for traction drives-solar powered pump drives

UNIT-V	**DESIGN OF ELECTRICAL DRIVES**	9

~~Traction drives-conventional DC and AC traction drives-poly phase AC motor for traction drives-solar powered pump drives- Electric vehicles-Design of electrical vehicle -~~ 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- converter selection and characteristics.

Contact Hours	**:**	**45**

- Determine the motor for an electric drive by analysing the dynamic and steady state characteristics.
- Analyse and implement the drive system using DC motors.

●	Evaluate and implement the drive system using AC motors.
●	Realize a drive system using special electrical machines.
●	Synthesize and develop closed loop DC drive

Text Book(s):

1	Vedam Subramanyam, " Electric Drives Concepts and Applications ", 2e, McGraw Hill, 2016
2	Shaahin Felizadeh, "Electric Machines and Drives", CRC Press (Taylor and Francis Group), 2013.
3	John Hindmarsh and Alasdain Renfrew, "Electrical Machines and Drives System," Elsevier 2012.
4	N.K. De., P.K. SEN" Electric drives" PHI, 2012
5	Theodore Wildi, " Electrical Machines ,Drives and power systems ,6th edition, Pearson Education ,2015
6	G.K. Dubey ,"Fundamentals of Electrical Drives" Narosa; Second Edition,January 2010
7	R.Krishnan , "Electric Motor Drives – Modelling, Analysis and Control" , Pearson Education India; 1st edition,January 2015

Reference Books(s) / Web links:

1	John Hindmarsh and Alasdain Renfrew, "Electrical Machines and Drives System," Elsevier2012.
2	Shaahin Felizadeh, "Electric Machines and Drives", CRC Press(Taylor and Francis Group), 2013
3	S.K.Pillai, "A First course on Electrical Drives", Wiley Eastern Limited, 1993.
4	S. Sivanagaraju, M. Balasubba Reddy, A. Mallikarjuna Prasad, "Power semiconductor drives", PHI, 5th printing, 2013.
5	N.K.De., P.K.SEN, "Electric drives" , PHI, 2012.
6	Vedam Subramanyam, "Thyristor Control of Electric Drives", Tata McGraw Hill, 2007.
7	Bimal K Bose, "Modern Power Electronics and Drives', pearson,2016
8	https://www.youtube.com/watch?v=2Gjs7IPOCXs
9	https://www.scribd.com/doc/29764542/Power-Electronics-Converters-Applications-and-Design

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	1					1		1		1	1	1		
CO 2	2	3	3	1		2			2		1	2	3	2	3
CO 3	2	3	3	2		2			1		2	2	3	2	3
CO 4	2	3	3	2		2			1		2	2	3	2	3
CO 5	2	3	3	3	1	1			1		1	1	3	3	3
Average	**2.2**	**2.6**	**2.4**	**1.6**	**0.2**	**1.4**	**0.2**		**1.2**		**1.4**	**1.6**	**2.6**	**1.8**	**2.4**

Subject Code	Subject Name	Category	L	T	P	C
EE23613	**ELECTRIC ENERGY UTILIZATION AND CONSERVATION**	**PC**	**3**	**0**	**0**	**3**

Objectives:

●	To learn the energy saving concept by different ways of illumination.
●	To inculcate the different methods of electric heating and electric welding.
●	To impart knowledge on the fundamentals and recent trends in electric traction.
●	To provide knowledge on the concepts of energy management and audit.
●	To impart knowledge on energy saving with the help of case studies.

UNIT-I	**ILLUMINATION**	**9**

Introduction - definition and meaning of terms used in illumination engineering - classification of light sources - 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.

UNIT-II	**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 – ultrasonic welding.

UNIT-III	**ELECTRIC TRACTION**	**9**

Fundamentals of 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 - recent trends in electric traction- Hybrid Electric Vehicles.		
UNIT-IV	**ENERGY CONSERVATION AND AUDIT**	**9**
Need of Energy Audit - Types of energy audit- Energy audit approach- understanding energy costs- Bench marking- Energy performance- Matching energy use to requirement-Maximizing system efficiencies- optimizing the input energy requirements- Energy Audit instruments.		
UNIT-V	**ENERGY SAVINGS AND CASE STUDIES**	**9**
Case study – simple calculations of energy savings and conservation in process equipment like boiler, heat exchanger, concept of energy saving in electrical and thermal unit.		
	Contact Hours :	**45**

Course Outcomes: On completion of course, students will be able to	
●	realize the design of illumination systems with energy saving method.
●	illustrate the operation of various type of electric heating and electric welding.
●	realize the various traction motor controls used in electric traction.
●	estimate the energy audit approach with maximizing system efficiencies.
●	evaluate the energy savings case study like boiler and heat exchanger
Text Book (s):	
1	N.V. Suryanarayana, "Utilisation of Electric Power", Wiley Eastern Limited, New Age International Limited, 2nd edition, Reprint 2017.
2	J.B.Gupta, "Utilization of Electric power and Electric Traction", S.K.Kataria and Sons, 2013.
3	G.D.Rai, "Non-Conventional Energy Sources", Khanna Publications Ltd., New Delhi, 1997.
Reference Books(s) / Web links:	
1	R.K.Rajput, "Utilisation of Electric Power", Laxmi publications Private Limited., 2007.
2	H.Partab, "Art and Science of Utilisation of Electrical Energy", Dhanpat Rai and Co., NewDelhi, 2004.
3	C.L.Wadhwa, "Generation, Distribution and Utilisation of Electrical Energy", New AgeInternational Pvt. Ltd., 2003.
4	S. Sivanagaraju, M. Balasubba Reddy, D. Srilatha, "Generation and Utilization of Electrical Energy", Pearson Education, 2010.
5	Donals L. Steeby, "Alternative Energy Sources and Systems", Cengage Learning, 2012.
6	Soni, Gupta and Bhatnagar, "A Course in Electrical Power", Dhanapat Rai & sons, 1987.
7	Dr. S.L.Uppal, "Electrical Power", Khanna Publications, 2007.
Web links:	
1	https://books.google.co.in/books/about/Electric_Energy_Generation_Utilization_a.html?id=Ddde4guNXcwC&redir_esc=y
2	https://nvlpubs.nist.gov/nistpubs/Legacy/SP/nbsspecialpublication403.pdf
Suggested Activities: To conduct energy audit for the college or department	
Suggested Evaluation methods: weightage to be given to practical work on energy audit	

COs/POs&PSOs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO 1	3	3	3	2											
CO 2	3	3	3	2											
CO 3	3	3	3	3	2		3								
CO 4	3	3	3	2	2	2	2				2				
CO 5	3	3	3	2	2	2	2				2				
Average	**3**	**3**	**3**	**2**	**2**	**2**	**2.33**	**-**	**-**	**-**	**1**	**-**			

Course Code	Course Title(Laboratory Integrated Theory Course)	Category	L	T	P	C
EE23631	APPLICATIONS OF IoT IN ELECTRICAL ENGINEERING	PC	2	0	2	3

Objectives:

- To introduce the fundamentals of IoT.
- To impart knowledge on different communicating IOT protocols.
- To acquire the concept of IOT based sensors and actuators.
- To learn about Cloud based data collection methods.
- To develop IoT infrastructure for popular applications

UNIT-I	**Internet of Things :An Overview**	**6**

IOT conceptual framework, Smart and Hyperconnected Devices, conceptual framework, architectural view, M2M, M2M to IOT.

UNIT-II	**DESIGN PRINCIPLES FOR CONNECTED DEVICES**	**6**

IoT/M2M systems layers, Communication Technologies-RFID, Bluetooth, ZigBee, LAN, WLAN802.11, device management at gateway, MQTT Protocol, SOAP.

UNIT-III	**Sensors and Wireless Sensor Networks**	**6**

Data reading from Sensors, Industrial IoT- participatory sensing process, Automotive IoT, ACTUATOR, sensor and actuator control using g MQTT-Overview of an Internet-connected car.

UNIT-IV	**IoT Data Collection Using a Cloud Platform**	6

Cloud based data collection, storage and computing, everything as a service, cloud service models, IoT Cloud-based Data Collection, Storage - Public Cloud IoT Platforms.

UNIT-V	**CASE STUDIES**	**6**

Smart Grid, Smart Metering, ATM Premises Monitoring Project, Energy management system – Industrial automation – Smart Agriculture System – Smart Cities.

Contact Hours	**:**	**30**

List of Experiments

1	To interface the different types of sensors through multithreading.
2	To interface the different types of relays and actuators through multithreading.
3	To generate the PWM signals through cloud-controlled inputs
4	To read and write the data from open cloud sources
5	To implement the cloud-based motor control process
6	To develop the cloud controlled home automation system.

Contact Hours	**:**	**30**
Total Contact Hours	**:**	**60**

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

- Understand the reference architecture and various IoT levels
- Comprehend the various IoT related protocols
- Analyse the concept of IOT based sensors and actuators
- design methodology and constraints in IoT based data handling
- Evaluate applications of IoT in real time scenario

Suggested Activities

- To carry on Practical implementation of electrical systems using IoT

Suggested Evaluation Methods

- Mini project

Text Book (s):

1	Raj Kamal - Internet of Things-Architecture and Design Principles- 2nd Edition. McGraw Hill; (14 June 2022);
2	Arshdeep Bahga, Vijay Madisetti, ―Internet of Things – A hands-on approach‖, Universities Press, 2015
3	David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry, ―IoT Fundamentals: Networking Technologies, Protocols and Use Cases for Internet of Things, Cisco Press, 2017

Reference Books(s) :

1	Olivier Hersent, David Boswarthick, Omar Elloumi , ―The Internet of Things – Key applications and Protocols‖, Wiley, 2012

2	Jan Holler, Vlasios Tsiatsis , Catherine Mulligan, Stamatis , Karnouskos, Stefan Avesand, David Boyle, "From Machine-to-Machine to the Internet of Things - Introduction to a New Age of Intelligence", Elsevier, 2014.
3	Dieter Uckelmann, Mark Harrison, Michahelles, Florian (Eds), ―Architecting the Internet of Things‖, Springer, 2011.
4	Daniel Minoli, "Building the Internet of Things with IPv6 and MIPv6: The Evolving World of M2M Communications", ISBN : 978-1-118-47347-4, Wiley Publications
Web links :	
1	https://docs.aws.amazon.com/?nc2=h_ql_doc_do
2	https://thingspeak.com/channels

Lab Equipments Required

	Name of the Equipment	Quantity Required	Remarks
1	Arduino Mega Board with Cable	20	Main base board for data processing
2	NodeMcu Board with Cable	10	To Connect the device with cloud through WiFi
3	Arduino Sensor kit	2	To accrue signal variation from the device
4	Arduino Ethernet Shield	2	To create the internet connection through RJ-45
5	D-Link DIR-825 AC 1200 Wi-Fi Dual-Band Gigabit (LAN/WAN) ROUTER	1	To Provide the Internet Connection for LAB

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	1	2	2	1	3	1						2		1	3
CO 2	2	1	2	1	1	2	1				1	1		1	3
CO 3	1	1	3		1		1				2	1	1	2	3
CO 4	2	2			3							1		1	3
CO 5	2	2	1	2	2		2				1	1	1	1	3
Average															

Subject Code	Subject Name	Category	L	T	P	C
EE23P**	**PROFESSIONAL ELECTIVE-II**	**PE**	**3**	**0**	**0**	**3**

Subject Code	Subject Name	Category	L	T	P	C
EE23P**	**PROFESSIONAL ELECTIVE-III**	**PE**	**3**	**0**	**0**	**3**

Course Code	Course Title (Laboratory Course)	Category	L	T	P	C
EE23621	**Power Electronics and Drives Laboratory**	**PC**	**0**	**0**	**2**	**1**

Objectives:	
•	To know the different ways of triggering SCR.
•	To infer the different commutation techniques of SCR.
•	To explore the conversion of AC to DC using controlled converter circuits.
•	To analyze and infer the different SMPS topology
•	To inculcate the knowledge on inverter and AC to AC conversion circuits
List of Experiments	
1	Thyristor triggering schemes
2	Thyristor commutation techniques
3	Single phase (1 and 2 pulse) phase controlled rectifier fed DC Motor.
4	Three phase (3 and 6 pulse) phase controlled rectifier fed DC Motor.
5	SMPS (Basic Isolated and non- isolated topology) for battery charging applications
6	Resonant DC-DC converter.

7	Single phase PWM fed Induction motor drive.
8	Three phase PWM fed Induction motor drive.
9	AC Voltage Controller
10	Single and three phase cycloconverter.
	Total Contact Hours : 30

Course Outcomes:

On completion of the course, students will be able to

- To design and develop a firing module for a phase controlled rectifier circuits.
- To control the DC motor using phase controlled rectifier circuits.
- To develop a SMPS for a specific application.
- To control and analyze the v/f control of induction motor.
- To generate an AC supply with variable voltage and frequency.

Suggested Activities

- Students should develop a firing and power module to control the speed of DC motor.
- Students should implement the different PWM schemes in MATLAB/SIMULINK software.

Suggested Evaluation Methods

- Inferring, examination and Interaction to know the depth of understanding in the subject.

Lab Equipments Required

S.No	Name of the Equipment	Quantity Required
1	Discrete components (Resistor , pot, capacitor, MOSFET, IGBT, UJT, Diode, LED, Glass fuse holder and fuse, pulse transformer, BJT, TRIAC)	Resistor 1k, 1.5k, 2.2k, 4.7k, 5.6k (each 30 of 0.5 W) Capacitor (0.1µf, 0.01µf, 1µf, 10µf and 1000µf) each 30. Power Semiconductor devices each 10. Pulse transformer (1:1 – 5No's, 1:1:1,-5no's)
2	Single phase half and full controlled converter .(Firing and power circuit module)	2
3	Three phase half and full controlled converter (Firing and power circuit module)	2
4	SMPS module (Buck, Boost, Forward and Fly back)	2
5	Resonant DC- DC converter	2
6	1ϕ PWM inverter trainer kit with firing circuit	2
7	3ϕ PWM inverter trainer kit with firing circuit	2
8	AC Voltage controller trainer kit	2
9	Cycloconverter (power + firing circuit)	2

COs/POs &PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3		2	2	2								2	2	3
CO 2	3	3	2	2	2			2					2	2	3
CO 3	3	3	2	2	2							2	2	2	3
CO 4	3	3	2	2	2							2	2	2	3
CO 5	3	3	2	2	2							2	2	2	3
Average	**3**	**3**	**2**	**2**	**2**			**2**				**2**	**2**	**2**	**3**

Subject Code	Subject Name	Category	L	T	P	C
EE23622	APPLICATIONS OF AI AND ML IN ELECTRICAL ENGINEERING	PC	0	0	4	2

Objectives:

●	To introduce basic Machine Learning (ML) algorithms
●	To provide knowledge on basic Machine Learning (ML) algorithms for Power Converter and Drive applications
●	To impart knowledge on Machine Learning (ML) and Artificial Intelligent (AI) techniques to Electric Power System applications
●	To impart knowledge on the design of Digital twin model for Renewable Energy Applications.
●	To familiarize the Neural Network, Fuzzy logic control concepts for the design of MPPT in Renewable Energy Applications.

List of Experiments

1	Implement and demonstrate the FIND-S algorithm for finding the most specific hypothesis based on a givenset of training data samples.
2	Demonstrate the working of the decision tree based ID3 algorithm. Use an appropriate data set for buildingthe decision tree and apply this knowledge to classify a new sample.
3	Implement k-Nearest Neighbour algorithm to classify the data set. Print both correct and wrong predictions.
4	Predict the amount of copper needed depending upon the Power rating of the Generator.
5	Predict the price of new motor from the data available over a Period of 10 years.
6	Standby Diesel Generator to be switched on or not based on the Energy Supply (renewable and Electricity Board) and Demand data taken over a period of 1 year for an Industry.
7	Power system fault detection using k-Nearest Neighbor algorithm
8	Load forecasting using Linear Regression algorithm
9	Design of Proportional Integral (PI) Controller Parameters Using Genetic Algorithm (GA) for VMC
10	Design of Proportional Integral (PI) Controller Parameters Using Ant Colony Optimization Algorithm
11	Analysis and Design of Digital twin model for Photovoltaic sourced modules
12	Analysis and Design of Digital twin model for motor drive inverter system
13	Analysis and Design of Digital twin development and deployment for Wind turbine
14	ANFIS Based Maximum Power Point Tracking (MPPT) MPPT for Solar PV System

Total Contact Hours	**:**	**60**

Course Outcomes:

On completion of the course, students will be able to

●	To develop the basic Machine Learning (ML) algorithms
●	To apply basic Machine Learning (ML) algorithms for the control of Power Converters and Drives
●	To apply Machine Learning (ML) and Artificial Intelligent (AI) techniques to Electric Power System applications
●	To design analyze the Digital twin model for Renewable Energy Applications.
●	To apply the Neural Network, Fuzzy logic control concepts for the design of MPPT in Renewable Energy Applications.

TEXT BOOKS

1	Laurance Fausett, Englewood cliffs, N.J., “Fundamentals of Neural Networks”, Pearson Education, 1994.
2.	Shalev-Shwartz,S., Ben-David,S., (2014), Understanding Machine Learning: From Theory to Algorithms, Cambridge University Press
3.	Nagrath I.J. and Kothari D.P., ‘Modern Power System Analysis’, Tata McGraw-Hill, Fourth Edition, 2011.
4.	Y. S. Abu-Mostafa, M. Magdon-Ismail, and H.-T. Lin, “Learning from Data”,AMLBook Publishers, 2012.
5.	P. Flach, “Machine Learning: The art and science of algorithms that make sense of data”, Cambridge University Press, 2012.
6.	C. M. Bishop, “Pattern Recognition and Machine Learning”, Springer, 2007

REFERENCE BOOKS	
1.	M.Gen and R,Cheng, "Genetic algorithms and Optimization", Wiley Series in Engineering Design and Automation, 2000.
2.	Kundur P., 'Power System Stability and Control, Tata McGraw Hill Education Pvt. Ltd., New Delhi,10th reprint, 2010.

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	2	3	3	1	1	1	3	3	3	3	3	2	3
CO 2	3	3	2	3	3	1	1	1	3	3	3	3	3	-	3
CO 3	3	3	3	3	3	1	1	1	3	3	3	3	3	3	3
CO 4	3	3	3	3	3	2	2	1	3	3	3	3	3	3	3
CO 5	3	3	3	3	3	2	2	1	3	3	3	3	3	3	3
Average	**3**	**3**	**2.6**	**3**	**3**	**1.4**	**1.4**	**1**	**3**	**3**	**3**	**3**	**3**	**2.2**	**3**

Subject Code	**Subject Name (Theory course)**	**Category**	**L**	**T**	**P**	**C**
GE23621	**PROBLEM SOLVING TECHNIQUES**	**EEC**	**0**	**0**	**2**	**1**

Objectives:	
●	**To improve the numerical ability.**
●	**To improve problem-solving skills.**

COURSE TOPICS	
S.NO	TOPIC NAME
1	Numbers system
2	Reading comprehension
3	Data arrangements and Blood relations
4	Time and Work
5	Sentence correction
6	Coding & Decoding, Series, Analogy, Odd man out and Visual reasoning
7	Percentages, Simple interest and Compound interest
8	Sentence completion and Para-jumbles
9	Profit and Loss, Partnerships and Averages
10	Permutation, Combination and Probability
11	Data interpretation and Data sufficiency
12	Logarithms, Progressions, Geometry and Quadratic equations.
13	Time, Speed and Distance

Total Contact Hours	**:**	**30**

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

●	Have mental alertness
●	Have numerical ability
●	Solve quantitative aptitude problems with more confident

SEMESTER VII

Course Code	Course Title(Theory Course)	Category	L	T	P	C
EE23711	SMART GRID	PC	3	0	0	3

Course Objectives:

- To provide knowledge on the concepts of Smart Grid and its present developments
- To learn the different Smart Grid technologies.
- To impart knowledge about different smart meters and advanced metering infrastructure.
- To gain knowledge on power quality management in Smart Grids
- To acquire knowledge on high performance computing for Smart Grid applications.

UNIT-I INTRODUCTION **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, Case study of 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, Plug in Hybrid Electric Vehicles (PHEV), Vehicle to Grid, Smart Sensors, Home & Building Automation.

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.

Contact Hours : 45

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

- Comprehend the concepts of smart grid and its present developments.
- Realize the different smart grid technologies.
- Describe about smart meters and advanced metering infrastructure.
- Analyze the power quality issues in smart grid
- Realize about high performance computing for Smart Grid applications

Suggested Activities

- Technical quiz
- Industrial visit to power station

Suggested Evaluation Methods

- CAT Exam , Assignments and Viva-Voce

Text Book (s):

1. Stuart Borlase “Smart Grid: Infrastructure, Technology and Solutions”, CRC Press 2012.
2. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jian zhong Wu, Akihiko Yokoyama, “SmartGrid: Technology and Applications”, Wiley, 2012..

Reference Books(s) :

1. Vehbi C. Güngör, DilanSahin, 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.
2. Xi Fang, SatyajayantMisra, GuoliangXue, and Dejun Yang “Smart Grid – The New and Improved Power Grid: A Survey”, IEEE Transaction on Smart Grids.

3	FabioToledo "Smart Metering Handbook", Penn Well Corporation, 2013
Web links :	
1	https://www.academia.edu/1526326/Smart_Grid_Technologies_Communication_Technologies_and_Standards
2	https://webuser.hs-furtwangen.de/~heindl/ebte-2014ws-Pre_Smart%20Grid%20Technologies_WS_14_15.pdf

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	3	3	2	2		2		2	2	3	3	3
CO 2	3	3	3	3	3	2	2		2		2	2	3	3	3
CO 3	3	3	3	3	3	2	2		2		2	2	3	3	3
CO 4	3	3	3	3	3	2	2		2		2	2	3	3	3
CO 5	3	3	3	3	3	2	2		2		2	2	3	3	3
Average	**3**	**3**	**3**	**3**	**3**	**2**	**2**		**2**		**2**	**2**	**3**	**3**	**3**

Course Code	**Course Title(Theory Course)**	**Category**	**L**	**T**	**P**	**C**
EE23712	**POWER SYSTEM OPERATION AND CONTROL**	**PC**	**3**	**0**	**0**	**3**

Course Objectives:

- To gain knowledge on the overview of power system operation and control.
- To impart knowledge on modeling of real power-frequency dynamics and design of real power-frequency controller.
- To provide knowledge on reactive power-voltage interaction and the control actions to be implemented for maintaining the voltage profile against varying system load.
- To learn the economic operation of power system.
- To get familiarized with SCADA and its application for real time operation and control of power systems.

UNIT-I **INTRODUCTION** **9**

Power scenario in Indian grid – National and Regional load dispatching centers - An overview of power system operation and control - system load variation - load characteristics -load curves and load-duration curve - load factor - diversity factor - Reserve requirements: Installed reserves, spinning reserves, cold reserves, hot reserves - load forecasting - load forecasting methods - plant level and system level controls.

UNIT-II **REAL POWER - FREQUENCY CONTROL** **9**

Basics of speed governing mechanism and modelling - speed-load characteristics – load sharing between two synchronous machines connected in parallel - control area concept - LFC control of a single-area system - static and dynamic analysis of uncontrolled and controlled cases - two-area system –modelling - static analysis of uncontrolled case - tie line with frequency bias control - state variable model - integration of economic dispatch control with LFC.

UNIT-III **REACTIVE POWER–VOLTAGE CONTROL** **9**

Basics of reactive power control – Relation between voltage, power and reactive power at a node - Generation and absorption of reactive power - excitation systems –modelling - static and dynamic analysis - stability compensation - methods of voltage control: tap changing transformer, SVC (TCR + TSC) and STATCOM.

UNIT-IV **UNIT COMMITMENT AND ECONOMIC DISPATCH** 9

Formulation of economic dispatch problem – I/O cost characterization – incremental cost curve –coordination equations without and with loss (No derivation of loss coefficients) - solution by direct method and λ-iteration method - statement of unit commitment problem – priority-list method – forward dynamic programming.

UNIT-V **COMPUTER CONTROL OF POWER SYSTEMS** **9**

Need for computer control of power systems - concept of energy control centre - functions – system monitoring - data acquisition and control - system hardware configuration – SCADA and EMS functions - network topology - state estimation – WLSE - Contingency Analysis - Congestion management - state transition diagram showing various state transitions and control strategies.

Contact Hours : 45

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

•	realize the overview of power system operation and control.
•	analyze load frequency control of single area system and two area power systems.
•	analyze the automatic voltage regulator and other reactive power - voltage control methods.
•	evaluate the optimal unit commitment schedule and optimal economic dispatch.
•	comprehend the various computer controls of power systems using simulation
Suggested Activities	
● Technical quiz on load frequency control and Automatic Voltage Regulator ● Industrial visit to power station	
Suggested Evaluation Methods	
• CAT Exam , Assignments and Viva-Voce	
Text Book (s):	
1	Olle.I.Elgerd, "Electric Energy Systems theory - An introduction", Tata McGraw Hill Education Pvt. Ltd., New Delhi, 34th reprint, 2010.
2	Allen. J. Wood and Bruce F. Wollenberg, "Power Generation, Operation and Control", John Wiley& Sons, Inc., Third Edition, 2013.
3	Abhijit Chakrabarti, Sunita Halder, "Power System Analysis Operation and Control", PHI learning Pvt. Ltd., New Delhi, Third Edition, 2010.
Reference Books(s) :	
1	D.P. Kothari and I.J. Nagrath, "Modern Power System Analysis", Third Edition, Tata McGraw Hill Publishing Company Limited, New Delhi, 2003.
2	Robert H. Miller, James H. Malinowski, 'Power system operation', Tata McGraw-Hill, 2009
3	L.L. Grigsby, "The Electric Power Engineering, Hand Book", CRC Press & IEEE Press, 2001.
4	Kundur P., Power System Stability and Control, McGraw Hill Education Pvt. Ltd., New Delhi, 12th reprint, 2015.
Web links :	
1	http://nptel.ac.in/courses/108101040
2	https://cea.nic.in/dashboard/?lang=en

COs/POs&PSOs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO 1	3	3	3	3	3	2	2		2		2	2	3	3	3
CO 2	3	3	3	3	3	2	2		2		2	2	3	3	3
CO 3	3	3	3	3	3	2	2		2		2	2	3	3	3
CO 4	3	3	3	3	3	2	2		2		2	2	3	3	3
CO 5	3	3	3	3	3	2	2		2		2	2	3	3	3
Average	**3**	**3**	**3**	**3**	**3**	**2**	**2**		**2**		**2**	**2**	**3**	**3**	**3**

Subject Code	**Subject Name (Lab oriented Theory Courses)**	**Category**	**L**	**T**	**P**	**C**
EE23731	**RENEWABLE ENERGY SYSTEMS**	**PC**	**3**	**0**	**2**	**4**
Objectives:						
●	To impart knowledge on general physical mechanism of energy conversion.					
●	To provide knowledge on renewable energy generation systems, such as wind and solar energy generations.					
●	To familiarize the biomass energy systems					
●	To teach the concept of tidal energy and fuel cell and other sources					
●	To expose the concept of micro generation systems					
UNIT-I	**ENERGY SCENARIO**	9				
Classification of energy sources–Worldwide Potentials of these sources –Energy needs of India – Energy efficiency – Energy security – Energy and its environmental impacts– Global environmental concern – Kyoto Protocol – Concept of						

Clean Development Mechanism (CDM) and Prototype Carbon Funds (PCF) – Factors favoring and against renewable energy generation and integration		
UNIT-II	**SOLAR ENERGY**	9
Solar thermal Power Plant – Types of Solar thermal collectors and Applications – Photo Voltaic (PV) technology – Types of Solar Panels – Solar PV Characteristics – Equivalent circuit- mathematical modeling – PV Array design – Maximum power point tracking – Charge Controllers – Sizing & Solar PV System Design - Standalone and grid interactive systems, Grid Integration issues in Solar PV system, Smart Grid and Solar Energy – Introduction to Building integrated PV systems		
UNIT-III	**WIND ENERGY**	9
Wind Energy – Mathematical Modeling - Power extracted from wind –wind speed Characteristics – Types of Wind Power Plants – Construction and Working of Wind Power Plants- Types of Turbine – Choice of generators- Introduction to Induction generator- Doubly fed Induction generator – Turbine rating – Electrical load matching – Variable speed operation- overview of permanent magnet synchronous generator – Maximum power operation – Control strategy – Stand alone and grid connected operation- Grid integration issues in Wind Power Plants		
UNIT-IV	**OTHER ENERGY SOURCES**	9
Biomass – Various resources – Energy contents – Technological advancements – Conversion of biomass in other form of energy – solid, liquid and gases – Gasifiers – Biomass fired boilers – Co firing – Generation from municipal solid waste – Issues in harnessing these sources – Hydro energy – Feasibility of small, mini and micro hydel plants: scheme, layout and economics – Tidal and wave energy – Geothermal and Ocean-Thermal Energy Conversion (OTEC) systems – Schemes, feasibility and viability.		
UNIT-V	**ENERGY STORAGE AND HYBRID SYSTEM CONFIGURATIONS**	9
Energy storage – Recent Advances in energy storage technologies - Battery – Types – Equivalent circuit- Battery storage modeling – Performance characteristics –design –charge regulators – Battery management System – Fly wheel - Fuel cell - Ultra capacitors – Benefits over battery. Introduction to vehicle to grid systems – PV,Wind and Diesell hybrid systems		
	Contact Hours : 45	

	List of Experiments
1	I-V and P-V Characteristics of Solar cell
2	Simulation of Perturb and Observe MPPT Algorithm for PV array
3	Modelling and simulation of self-excited Induction generator.
4	Modelling and simulation of DFIG.
5	Experimental study of permanent magnet synchronous generator.
6	Simulation of isolated hybrid systems
7	Modelling and simulation of Fuel Cell.
8	Modelling and simulation of energy storage system.
9	Characteristics of Partial Shading in PV Panel
10	Power quality performance analysis for nonlinear loads.
11	Experimental validation of self-excited Induction generator.
12	Grid synchronization of PV sourced inverter. (demo)

	Contact Hours	**:**	**30**
	Total Contact Hours	**:**	**75**

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

●	determine the general physical mechanism of energy conversion
●	evaluate the function of micro generation systems
●	analyze the challenges and problems associated with the use of various energy sources, including fossil fuels, with regard to future supply and the environment
●	realize the basic electrical concepts and system components
●	know the information on renewable energy technologies as a basis for further investigation and evaluation.

Text Book (s):

1	Rai, G. D., "Non Conventional Energy Sources", Khanna Publishers,18th edition 2017.
2	Rao S. Paruklekar, "Energy Technology – Non-Conventional, Renewable and Conventional", Khanna Publishers, 3rd edition (2009).

Reference Books(s) / Web links:

1	Openshaw Taylor, E., "Utilisation of Electric Energy in SI Units.", Orient Longman Ltd,2007
2	Uppal, S.L., "Electric Power", 13th Edition, Khanna Publishers, 2009.
3	Mukund R. Patel, "Wind and Solar Power Systems", CRC Press LLC, second edition (15 July 2005)

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3			2	2							3	3
CO 2	3	3	3	2		1	1						3	3	3
CO 3	3	3	3	2							1		2	3	3
CO 4	3	3	3	3					2		1			3	3
CO 5	3	3	3	1										3	3
Average	**3**	**3**	**3**	**2**		**1.5**	**1.5**		**2**		**1**		**2.5**	**3**	**3**

Subject Code	Subject Name	Category	L	T	P	C
EE23P**	**PROFESSIONAL ELECTIVE-IV**	**PE**	**3**	**0**	**0**	**3**

Course Code	Course Title (Laboratory Course)	Category	L	T	P	C
EE23721	**POWER SYSTEM SIMULATION LABORATORY**	PC	**0**	**0**	**4**	**2**

Objectives:

- To impart knowledge on load flow solution methods through simulation
- To gain knowledge on fault analysis through simulation
- To provide the knowledge about transient stability in power systems through simulation
- To acquire knowledge on economic dispatch of power plants through simulation
- To learn the functioning of FACTS controllers in power systems through simulation

List of Experiments

1	Formation of Bus Admittance and Impedance Matrices.
2	Power Flow Analysis using Gauss-Seidel Method and Newton Raphson Method.
3	Symmetric and unsymmetrical fault analysis.
4	Transient stability analysis of SMIB System.
5	Simulation of load curve, load duration curve and calculation of power plant parameters.
6	Load – Frequency Dynamics of Single- Area and Two-Area Power Systems.
7	Analysis of Automatic Voltage Regulator.
8	Economic Dispatch without and with Transmission Loss in Power Systems.
9	Unit commitment using priority list method.
10	Simulation of FACTS controllers in power systems

Total Contact Hours : 45

Course Outcomes:

On completion of the course, students will be able to

- analyze the power flow using Gauss-Seidel and Newton Raphson methods in power systems
- evaluate symmetric fault and unsymmetrical fault currents in power systems
- determine the frequency deviation and voltage deviation during load variations in power systems
- realize the economic dispatch in power systems
- estimate the power system state with FACTS controller

Suggested Activities

- Simulation of experiment with real time power system data.

Suggested Evaluation Methods

- Conducting Viva-Voce

Lab Equipments Required

	Name of the Equipment	Quantity Required
1	Personal computers (Pentium-IV, 80GB, 512 MBRAM)	25
2	Printer laser	1
3	Dot matrix	1
4	Server (Pentium IV, 80GB, 1GBRAM) (High Speed Processor)	1
5	Software: any power system simulation software	5
6	Compliers: C, C++, VB, VC++	25

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	3	3	2	2		2		2	2	3	3	3
CO 2	3	3	3	3	3	2	2		2		2	2	3	3	3
CO 3	3	3	3	3	3	2	2		2		2	2	3	3	3
CO 4	3	3	3	3	3	2	2		2		2	2	3	3	3
CO 5	3	3	3	3	3	2	2		2		2	2	3	3	3
Average	**3**	**3**	**3**	**3**	**3**	**2**	**2**		**2**		**2**	**2**	**3**	**3**	**3**

Subject Code	Subject Name	Category	L	T	P	C
EE23722	**PROJECT WORK PHASE I**	**EEC**	**0**	**0**	**8**	**4**

Course Objectives:

- To develop their own innovative prototype.
- To train the students in preparing comprehensive project report

The students in a group of 3 to 4 works on a topic approved by the head of the department and prepares a comprehensive project report after completing the work to the satisfaction. 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 has to be submitted 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 Contact Hours	**:**	**120**

Course Outcomes:

- On Completion of the Phase-I project work, the students will be in a position to take up their final year Phase-II project work and find the solution by formulating the proper methodology.

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO 2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO 3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO 4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO 5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Average	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**

Subject Code	Subject Name	Category	L	T	P	C
EE23723	INTERNSHIP	EEC	0	0	2	1

SEMESTER VIII

Subject Code	Subject Name	Category	L	T	P	C
EE23P**	PROFESSIONAL ELECTIVE-V	PE	3	0	0	3
EE23P**	PROFESSIONAL ELECTIVE-VI	PE	3	0	0	3

Subject Code	Subject Name	Category	L	T	P	C
EE23821	PROJECT WORK PHASE II	EEC	0	0	12	6

Objectives:

- To develop the ability to solve a specific problem right from the identification from the extensive literature review till the successful solution of the same.
- To train the students in preparing the project reports and to face reviews and viva voce examination.

The students in a group of 3 to 4 works on a topic approved by the head of the department under the guidance of a faculty member and prepares a comprehensive project report after completing the work to the satisfaction of the supervisor. The progress of the project is evaluated based on a minimum of three reviews. The review committee may be constituted by the Head of the Department. A project report has to be submitted 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 Contact Hours	**:**	**180**

Course Outcomes:

- On Completion of the project work students will be in a position to take up any challenging practical problems and find the solution by formulating the proper methodology.

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO 2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO 3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO 4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO 5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Average	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**

PROFESSIONAL ELECTIVES
VERTICAL I - RENEWABLE ENERGY TECHNOLOGIES

Subject Code	Subject Name(Theory Course)	Category	L	T	P	C
EE23A11	SOLAR ENERGY SYSTEMS	PE	3	0	0	3

Objectives:

- To comprehend the fundamental concepts of solar radiation and measurement.
- To develop knowledge of the working principle of the solar photovoltaic system.
- To analyze the various solar photovoltaic systems and their applications.
- To learn about the solar thermal system and its applications.
- To learn the economic use of solar energy.

UNIT-I	SOLAR RADIATION AND MEASUREMENT	9

Sun as a source of energy, Solar radiation at the Earth's surface, Solar radiation analysis – Solar constant, electromagnetic energy spectrum, determination of earth-sun angles, solar time, solar angles, sunset, sunrise and day length, Measurement of average, direct and diffused Solar radiation - Pyroheliometer, Pyranometer, Sunshine recorder.

UNIT-II	SOLAR PHOTOVOLATIC FUNDAMENTALS	9

Electric power generation principles, PV Modules and arrays - Solar cell construction ,Different types of Solar cells, Electrical property and behavior of solar cell Series and parallel connections, power output and conversion efficiency, Advantages and disadvantages of PV solar energy conversion. Simulation of solar cell

UNIT-III	SOLAR PHOTOVOLATIC SYSTEMS	9

~~Balance of system~~(Types of solar PV systems), Standalone PV system, Grid-connected PV system, Storage of solar energy, Photovoltaic applications: Battery chargers, lighting systems, dc-drives and water pumping. - SIMULATION/EXPERIMENT/DESIGN

UNIT-IV	SOLAR THERMAL SYSTEMS	9

Principle of conversion of solar radiation into heat, Collectors used for solar thermal conversion: Flat plate collectors and Concentrating collectors, over view of solar ponds, Solar Thermal Power Plant, Solar cookers, Solar hot water systems, Solar dryers, Simulation of solar hot water systems

UNIT-V	ECONOMIC ANALYSIS	9

Economic Analysis: Initial and annual costs- definition of economic terms for a solar system- present worth calculation - annual savings - cumulative savings and life cycle savings - payback period.

Total Contact Hours	:	45

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

- Understand the fundamental aspects of measurement of solar radiation.
- Describe the working principle of solar photovoltaic system.
- Interpret the different configurations of solar Photovoltaic system.
- Illustrate the concept of solar thermal system
- Describe the various terms involved in the economic analysis.

Text Book (s):

1. G. D. Rai, "Solar Energy Utilization", 5th edition, Khanna Publishers, New Delhi,2013.
2. G.N. Tiwari, "Solar Energy- Fundamentals, design, modeling & applications", Narosa Pub., 2012.
3. H.P.Garg, "Advanced in Solar Energy Technology", D. Reidel Publishing Co., Drdricht.

Reference Books(s) :

1. Chetan Singh Solanki, "Solar Photovoltaics- Fundamentals, technologies and applications", PHI Learning Pvt. Ltd., 2013.
2. K.Sukhatme and S.P.Sukhatme "Solar Energy principles of thermal collection and storage" 4th Edition, Tata McGraw Hill education- New Delhi- 2017.
3. P. Jayarama Reddy, "Science and Technology of Photovoltaics", BS Publications, 2010.
4. Garg H P and Prakash J, "Solar Energy: Fundamentals & Applications", McGraw Hill - New Delhi- 2014.

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	2	2	-	2	2	1	1	-	1	1	3	1	-
CO 2	3	3	2	2	-	2	2	1	1	-	1	1	3	2	-
CO 3	3	3	2	2	2	2	2	1	1	-	1	1	3	2	3
CO 4	3	3	1	1	2	1	1	1	1	-	1	1	1	1	3
CO 5	3	3	1	1	-	1	1	1	1	-	1	1	1	1	-
Average	**3**	**3**	**1.63**	**1.6**	**1**	**1.6**	**1.6**	**1**	**1**	**-**	**1**	**1**	**2.2**	**1.4**	**1.2**

Subject Code	Subject Name (Theory Course)	Category	L	T	P	C
EE23A12	**WIND ENERGY CONVERSION SYSTEM**	**PE**	**3**	**0**	**0**	**3**

Objectives:

- To review the wind energy conversion system
- To learn the fundamental of wind energy conversion system and its control
- To demonstrate the fixed speed wind energy conversion system
- To understand the Doubly-fed induction generator-based wind energy conversion system
- To analysis the power quality performance of interconnected WECS

UNIT-I **INTRODUCTION** **9**

Introduction – Overview of Wind Energy Conversion Systems (WECS): Stand-alone and grid-connected applications, on-land and offshore applications -Costs of wind energy conversion systems – Wind Turbine Technology – Wind Energy Conversion System Configurations.

UNIT-II **FUNDAMENTALS OF WIND ENERGY CONVERSION SYSTEM CONTROL** **9**

Introduction – Wind Turbine Components: Turbine Blade, Pitch Mechanism, Gearbox, Rotor Mechanical Brake, Generator, Yaw Control, Wind Sensors (Anemometers) – Wind Turbine Aerodynamics- Tip Speed Ratio – Simple Momentum Theory, Sabinin's Theory – Maximum Power Point Tracking Control- Simulation of wind turbine characteristics

UNIT-III **FIXED SPEED WIND ENERGY CONVERSION SYSTEM** **9**

Introduction – Configuration of Fixed Speed WECS – Operation Principle: Fixed Speed Operation of Squirrel Cage Induction Generator, Two-Speed Operation of Fixed Speed WECS -Main Features and Drawbacks– Grid Connection with Soft Starter – Reactive Power Compensation; Simulation of Fixed Speed WECS

UNIT-IV **VARIABLE-SPEED WIND ENERGY CONVERSION SYSTEM** **9**

Introduction – Doubly-fed Induction Generator: Super and sub synchronous operation of DFIG, Unity power factor operation of DFIG, Leading and Lagging Power Factor Operation – Operation of Permanent Magnet-based WECS; - Simulation of PMSG based WECS

UNIT-V **NETWORK INTEGRATION OF WIND POWER** **9**

Introduction – Wind farm starting - Network voltage management: Voltage level issue - Network power quality management: Dips, Harmonics, Flicker – Transient system performance: Frequency performance and dynamic response, Transient response, Reactive Power Control of SG WECS.

Total Contact Hours : 45

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

- Able to review the progress of wind energy conversion system
- Explain the basics of wind energy conversion system
- Illustrate the concept of Fixed speed wind energy systems
- Describe the working principle variable speed wind energy systems
- Describe the various terms involved in the power quality analysis of WECs.

Text Book (s):

1. Power Conversion and Control Of Wind Energy Systems, Bin Wu, 2011, Wiley-IEEE
2. Wind Electrical Systems, S.N. Bhadra, 2005, Oxford

3	Wind Power Integration - Connection and System Operational Aspects, Brendan Fox, 2014, IET
Reference Books(s) :	
1	Joshua Earnest and Tore Wizelius, "Wind Power Plants and Project Development", PHI Learning Pvt. Ltd., New Delhi, 2011.
2	J. F. Manwell, J. G. McGowan and A. L. Rogers, "Wind Energy Explained – Theory, Design and Application", Wiley, 2009.
3	Earnest Joshua, "Wind Power Technology", Second edition, PHI Learning Pvt. Ltd., New Delhi, 2015.

COs/POs&PSOs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO 1	3	2	1								2	1	3		
CO 2	3	2	2	2								1	2	2	
CO 3	3	2	2	2	2						1	1	2	3	2
CO 4	3	2	2	2	2						1	1	2	3	2
CO 5	3	2	2	2	2						1	1	1	2	1
Average	**3**	**2**	**1.8**	**1.6**	**1.2**						**1**	**1**	**2**	**2**	**1**

Subject Code	**Subject Name (Theory Course)**	**Category**	**L**	**T**	**P**	**C**
EE23A13	**HYBRID ENERGY TECHNOLOGY**		**3**	**0**	**0**	**3**

Objectives:

- To provide knowledge about different types of hybrid energy systems.
- To teach the analysis of the various electrical generators used for Wind Energy Conversion Systems.
- To impart knowledge on designing power converters used in SPV Systems.
- To get familiarized with and explore the various power converters used in hybrid energy systems and to understand the importance of standalone and grid-connected operation in Hybrid renewable energy systems.
- To acquire knowledge on analyzing the performance of various hybrid energy systems.

UNIT-I	**INTRODUCTION TO HYBRID ENERGY SYSTEMS**	**9**

Hybrid Energy Systems – Need for Hybrid Energy Systems - Classification of Hybrid Energy systems – Importance of Hybrid Energy systems – Advantages and Challenges - Present Indian and international energy scenario of conventional and RE sources - Ocean and geyser energy, Introduction to Electric Mobility - Significance and Trends.

UNIT-II	**ELECTRICAL MACHINES FOR WIND ENERGY CONVERSION SYSTEMS (WECS)**	**9**

Review of reference theory fundamentals –Construction, Principle of operation and analysis: Squirrel Cage Induction Generator (SCIG), Doubly Fed Induction Generator (DFIG) - Permanent Magnet Synchronous Generator (PMSG), Integration of Electrical Machines in Electric Mobility Solutions

UNIT-III	**POWER CONVERTERS AND ANALYSIS OF SOLAR PV SYSTEMS**	**9**

Power Converters for SPV Systems - Line commutated converters (inversion-mode) - Boost and buck-boost converters- selection of inverter, battery sizing, array sizing - Analysis of SPV Systems - Block diagram of the solar PV systems - Types of Solar PV systems: Stand-alone PV systems, Integration of Solar PV in Electric Mobility

UNIT-IV	**ANALYSIS OF POWER CONVERTERS FOR HYBRID ENERGY SYSTEMS**	**9**

Introduction to Power Converters – Stand-alone Converters - AC-DC-AC converters - Bi-Directional Converters - Grid-Interactive Inverters - Matrix converter, Power Converters in Electric Mobility.

UNIT-V	**CASE STUDIES FOR HYBRID RENEWABLE ENERGY SYSTEMS**	**9**

Hybrid Systems- Range and type of Hybrid systems – Performance Analysis – Cost Analysis - Case studies of Diesel-PV, Wind-PV-Fuel-cell, Micro-hydel-PV, Biomass-Diesel-Fuel-cell hybrid systems, Case Studies of Hybrid Systems in Electric Mobility.

Total Contact Hours	**:**	**45**

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

- To develop the ability to analyze the impacts of hybrid energy technologies on the environment and demonstrate them to harness electrical power.

●	To comprehend the process of selecting a suitable Electrical machine for Wind Energy Conversion Systems and to apply the knowledge to simulate wind energy conversion systems.
●	To design power converters, including AC-DC, DC-DC, and AC-AC converters, for SPV systems.
●	To determine and evaluate the performance of power converters, such as AC-DC, DC-DC, and AC-AC converters, for hybrid energy systems.
●	To synthesize an understanding of hybrid renewable energy systems and realize their practical applications.
Suggested Activities	
●	Case studies can be done in hybrid renewable energy systems.
●	Use software tools to simulate hybrid energy systems.
Suggested Evaluation Methods	
●	Regular quizzes.
●	Assignment.
Text Book (s):	
1	Rai. G.D, "Non-conventional energy sources", Khanna publishers, 2010.
2	B.H.Khan "Non-conventional Energy sources ",TataMcGraw-hill Publishing Company, New Delhi, 2017.
3	Bahman Zohuri, "Hybrid Energy Systems"2022
Reference Books(s) :	
1	Ernst Joshua, Wind Energy Technology, PHI, India, 2018.
2	S.N.Bhadra, D. Kastha, & S. Banerjee "Wind Electrical Systems", Oxford University Press, 2009.
3	Rai. G.D," Solar energy utilization", Khanna publishers, 5th Edition, 2008.
4	Gray, L. Johnson, "Wind energy system", prentice hall of india, 1995.
5	Zohuri, B. Hybrid Renewable Energy Systems. In: Hybrid Energy Systems. Springer, 2018
Web links :	
	https://en.wikipedia.org/wiki/Hybrid_renewable_energy_system
	http://hybrid-renewable.blogspot.com/2011/03/importance-of-hybrid-energy-systems.html
	https://www.homerenergy.com/
	https://www.ge.com/renewableenergy/home

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	2	-	-	-	-	-	3	-	3	3	3	3
CO 2	3	3	3	2	3	-	-	-	-	3	-	3	3	3	3
CO 3	3	3	3	2	3	-	-	-	-	3	-	3	3	3	3
CO 4	3	3	3	2	3	-	-	-	-	3	-	3	3	3	3
CO 5	3	3	3	2	-	-	-	-	-	3	-	3	3	3	3
Average	3	3	3	2	3	-	-	-	-	3	-	3	3	3	3

Subject Code	**Subject Name (Theory Course)**	**Category**	**L**	**T**	**P**	**C**
EE23A14	**ENERGY STORAGE SYSTEMS**	**PE**	**3**	**0**	**0**	**3**

Objectives:

●	To understand the different types of energy storage technologies
●	To analyze Battery energy storage system
●	To analyze the Renewable energy storage system
●	To comprehend the principle of Fuel Cell energy storage system
●	To study the various applications of energy storage systems

UNIT-I	**INTRODUCTION**	**9**

Electricity - Role of energy storage systems and applications. Necessity of energy storage – types of energy storage – mechanical –chemical–electrical–electrochemical–electromagnetic–thermal – comparison of energy storage technologies.

UNIT-II	BATTERY ENERGY STORAGE SYSTEM	9
Fundamental concept of batteries – measuring of battery performance, charging and discharging, power density, energy density, and safety issues. Types of batteries – Lead Acid, Nickel -Cadmium, Zinc Manganese dioxide, Li-ion batteries. Battery critical parameters selection (voltage of cell –Specific energy–Charge (C-rate)–dis-Charge (C-rate),Cycle life–current density –Thermal runaway –Battery series parallel connection and String size–Battery mounting arrangement and installation. Safety of lithium-ion batteries. Types of lithium ion battery. Batteries for Electric Vehicles.		
UNIT-III	**RENEWABLE ENERGY STORAGE SYSTEM**	**9**
Solar energy, Wind energy, Pumped hydro energy, fuel cells. Energy storage in Micro-grid and Smart grid. Energy Management with storage systems, Increase of energy conversion efficiencies by introducing energy storage.		
UNIT-IV	**FUEL CELL ENERGY STORAGE SYSTEM**	**9**
Working Principle and Application of fuel cells: working principle of fuel cell, performance characteristics of fuel cells, efficiency of fuel cell, fuel cell stack, description of some commercially available fuel cell stacks.– Types Fuel Cell – Hydrogen oxygen cells–Hydrogen air cell–Hydrocarbon air cell–alkaline fuel cell–detailed analysis – advantages and disadvantages –Fuel Cell Electric Vehicles.		
UNIT-V	**ALTERNATE ENERGY STORAGE TECHNOLOGIES**	**9**
Super capacitors– Principles & Methods – Applications–Compressed air Energy storage–Battery-Super capacitor Hybrid Energy Storage Systems–Pumped Hydro Storage. Double-layer capacitors (DLC), Super conducting magnetic energy storage (SMES)Flywheel energy storage (FES), Electrochemical storage systems, Secondary batteries, Flow batteries, Chemical energy storage, Hydrogen (H2), Synthetic natural gas (SNG).		
	Total Contact Hours : 45	

Course Outcomes: On completion of the course, the students will

- Gain knowledge on different energy storage technologies
- Able to model the battery energy storage system
- Able to analyze a renewable energy storage system.
- Able to analyze the thermodynamics of fuel cell energy storage system
- Gain Knowledge on various applications of energy storage technologies and perform the selection

Text Book (s):

1	Energy Storage -Fundamentals, Materials and Applications, Robert Huggins, Springer, 2016
2	Energy Storage in Power Systems ,Francisco Díaz-González, Andreas Sumper, Oriol Gomis-Bellmunt 2016
3	Handbook on Battery Energy Storage System, Asian Development Bank
4	Handbook of lithium-ion battery pack design chemistry, components, types and terminology by Warner, John T, Elsevier.
5	Fundamentals and Application of Lithium-ion Battery Management in Electric Drive Vehicles by San Ping Jiang, Wiley.

Reference Books(s) :

1	Ibrahim Dincer and Mark A. Rosen, "Thermal Energy Storage Systems and Applications", John Wiley & Sons 2002
2	James Larminie and Andrew Dicks, "Fuel cell systems Explained", Wiley publications, 2003.
3	Ru-shiliu, Leizhang and Xueliang sun, "Electrochemical technologies for energy storage and conversion", Wiley publications, 2012.
4	A.G.Ter-Gazarian, "Energy Storage for Power Systems", Second Edition, The Institution of Engineering and Technology (IET) Publication, UK, (ISBN – 978-1-84919-219-4), 2011.
5	Pistoia, Gianfranco, and Boryann Liaw. Behaviour of Lithium-Ion Batteries in Electric Vehicles: Battery Health, Performance, Safety, and Cost. Springer International Publishing AG, 2018.
6	Lithium-Ion Batteries Basics and Applications by Reiner Korthauer, Springer.

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	2	-	-	-	-	-	3	-	3	3	3	3
CO 2	3	3	3	2	3	-	-	-	-	3	-	3	3	3	3

CO 3	3	3	3	2	3	-	-	-	-	3	-	3	3	3	3
CO 4	3	3	3	2	3	-	-	-	-	3	-	3	3	3	3
CO 5	3	3	3	2	-	-	-	-	-	3	-	3	3	3	3
Average	3	3	3	2	3	-	-	-	-	3	-	3	3	3	3

Subject Code	**Subject Name (Theory Course)**	**Category**	**L**	**T**	**P**	**C**
EE23A15	**GRID INTEGRATING TECHNIQUES AND CHALLENGES**		**3**	**0**	**0**	**3**

Objectives:

- To impart the integration of various renewable energy sources into the grid.
- To learn various grid issues due to renewable energy sources.
- To impart the dynamics of network due to windfarm.
- To study about power system stabilizers.
- To model the grid connected and standalone PV system.

UNIT-I	**INTRODUCTION**	**9**

Introduction to renewable energy grid integration - Concept of nano grid, micro grid and smart grid - Different types of grid interfaces - Issues related to grid integration of small and large scale of synchronous generator based - induction generator based and converter based sources together - Network voltage management - Power quality management (voltage dips, harmonics, flickers, and reactive power control) - Frequency management - Influence of WECS on system transient response - Interconnection standards and grid code requirements for integration.

UNIT-II	**NETWORK INFLUENCE OF GENERATION TYPE**	**9**

Network voltage management – Active power management – Network power quality management – Transient system performance – Fault level issues – Protection.

UNIT-III	**INFLUENCE OF WIND FARMS ON NETWORK DYNAMIC PERFORMANCE**	**9**

Dynamic Stability and its Assessment – Dynamic characteristics of Synchronous Generation - A Synchronizing power and Damping power model of a Synchronous Generator – Influence of Automatic Voltage Regulator on Damping – Influence on Damping of Generator Operating Conditions – Influence of Turbine Governor on Generator Operation – Transient Stability – Voltage Stability – Influence of Generation Type on Network Dynamic Stability – Dynamic Interaction of Wind Farms with the Network – influence of Wind Generation on Network Transient Performance.

UNIT-IV	**POWER SYSTEM STABILIZERS AND NETWORK DAMPING CAPABILITY OF WIND**	**9**

Power System Stabilizer for a Synchronous Generator - Power System Stabilizer for a DFIG - Power System Stabilizer for a FRC Wind Farm.

UNIT-V	**STAND ALONE AND GRID CONNECTED PV SYSTEM**	**9**

Solar modules – storage systems – Batteries for PV Systems – Charge Controllers – MPPT and Inverters – Power Conditioning and Regulation – protection – Types of Solar PV systems - standalone PV systems design – sizing – PV systems in buildings – design issues for central power stations – safety – Economic aspect – efficiency and performance – International PV programs.

Total Contact Hours	**:**	**45**

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

- Know about the integration of various renewable energy sources into the grid.
- Analyze various grid issues due to renewable energy sources.
- Analyze the dynamics of network due to windfarm.
- Know about power system stabilizers.
- Design the grid connected and standalone PV system.

Text Book (s):

1. Brian DAndrade The Power Grid, Academic Press, 1st Edition, 2017.
2. Yang Han, “Modeling and Control of Power Electronic Converters for Microgrid Applications”, Springer, 1st Edition 2022.

Reference Books(s) :

1. Siegfried Heier, “Grid Integration of Wind Energy: Onshore and Offshore Conversion Systems”, John Wiley & Sons, Ltd, 2014, 3rd Edition.

Web links :

1	https://www.academia.edu/14628492/Current_Power_Scenario_In_India
2	https://energyeducation.ca/encyclopedia/Electrical_grid
3	https://www.academia.edu/32120081/Power_Converters_Modeling_in_Matlab_Simulink_for_Micr
4	ogrid_Simulations_Power_Converters_Modeling_in_Matlab_Simulink_for_Microgrid_Simulations(continuation of 3)
4	https://dnv.com/services/wind-farm-control-and-grid-integration
5	https://www.wind-energy-the-facts.org/images/chapter2.pdf
6	https://onlinecourses.nptel.ac.in/noc23_ee124/preview
7	https://onlinecourses.nptel.ac.in/noc23_ee123/preview
8	https://www.alternative-energy-tutorials.com/solar-power/grid-connected-pv-system.html
7	https://www.academia.edu/14628492/Current_Power_Scenario_In_India to be deleted(repeatation of 1)
Suggested activities: Students will be trained in doing MATLAB simulation of grid integration of PV and wind renewable sources Simulation study of three phase inverters with fixed and sine PWM techniques,simulation and Design of buck/boost converters Simulate a Grid connected wind energy system with STATCOM and investigate the improvement in power quality.	
Suggested Evaluation methods: Assignment marks will be given for MATLAB simulation of standalone PV system and grid integration of PV system. Simulation study of three phase inverters with fixed and sine PWM techniques,simulation and Design of buck/boost converters Simulate a Grid connected wind energy system with STATCOM and investigate the improvement in power quality.	

COs/POs&PSOs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO 1	3	2	3	-	-	-	-	-	-	-	-	-	3	3	-
CO 2	3	2	3	3	2	-	-	-	-	-	-	-	3	3	-
CO 3	3	2	3	3	3	-	-	-	-	-	-	-	3	3	3
CO 4	3	2	3	-	-	-	-	-	-	-	-	-	1	1	-
CO 5	3	2	3	3	3	-	-	-	-	-	-	-	3	3	3
Average	**3**	**2**	**3**	**3**	**1.6**	-	-	-	-	-	-	-	**2.6**	**2.6**	**3**

Subject Code	**Subject Name (Theory Course)**	**Category**	**L**	**T**	**P**	**C**
EE23A16	**DESIGN MODELLING AND FABRICATION OF RENEWABLE ENERGY SYSTEM COMPONENTS**	**PE**	**3**	**0**	**0**	**3**

Objectives:

- To acquire the knowledge on renewable energy systems and technology
- To inculcate the knowledge on the Single phase grid-connected photovoltaic systems and three phase photovoltaic systems
- To provide exposure on the small wind energy systems
- To gain knowledge on the Doubly-fed induction generator based WECS

UNIT-I	**RENEWABLE ENERGY SYSTEMS: TECHNOLOGY OVERVIEW AND PERSPECTIVES**	**9**
Introduction-State of the Art- Examples of Recent Research and Development Challenges and Future Trends		
UNIT-II	**SINGLE-PHASE GRID-CONNECTED PHOTOVOLTAIC SYSTEMS**	**9**

Introduction- Demands for Grid-Connected PV Systems- modeling and control of grid-tied converters. Power Converter Technology for Single-Phase PV Systems, Transformer less AC-Module Inverters (Module-Integrated PV Converters, Transformer less Single-Stage String Inverters, DC-Module Converters in Transformer less Double-Stage PV Systems, International regulations, response to abnormal grid conditions (voltage deviations, frequency deviations),		
UNIT-III	**THREE-PHASE PHOTOVOLTAIC SYSTEMS: STRUCTURES, TOPOLOGIES**	**9**
Introduction-PV Inverter Structures, Three-Phase PV Inverter Topologies- -Control Building Blocks for PV Inverters, Modulation Strategies for Three-Phase PV Inverters, Implementation of the Modulation Strategies., Grid Synchronization, Implementation of the PLLs for Grid Synchronization, Current Control, Implementation of the Current Controllers, Maximum Power Point Tracking		
UNIT-IV	**SMALL WIND ENERGY SYSTEMS**	**9**
Introduction-Generator Selection for Small-Scale Wind Energy Systems- Turbine Selection for Wind Energy- Self-Excited Induction Generators for Small Wind Energy Applications- Permanent Magnet Synchronous Generators for Small Wind Power Applications- Grid-Tied Small Wind Turbine Systems- Grid requirements for wind turbine systems, grid code evolution, frequency and voltage deviation under normal operation, active and reactive power control in normal operation, behavior under grid disturbance.		
UNIT-V	**DOUBLY-FED INDUCTION GENERATOR-BASED WECS**	**9**
Introduction – Doubly-fed Induction Generator: Super and sub synchronous operation of DFIG, Unity power factor operation of DFIG, Leading and Lagging Power Factor Operation – Operation of Permanent Magnet-based WECS		
	Total Contact Hours : 45	

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

●	Illustrate the recent development of renewable energy systems and technology
●	Realize the functions of Single Phase Grid-Connected Photovoltaic Systems
●	Realize the three Phase Grid-Connected Photovoltaic Systems
●	Develop the small wind energy system.
●	Design the WECS using information on renewable energy technologies as a basis for further investigation and evaluation.

Text Book (s):

1	Fang Lin Luo and Hong Ye, "Renewable Energy Systems", Taylor & Francis Group, 2013.
2	Joshua Earnest and Tore Wizelius, “Wind Power Plants and Project Development”, Second Edition, PHI Learning Pvt. Ltd., New Delhi, 2017.
3	John Twidell and Tony Weir, “Renewable Energy Resources”, Second Edition, Taylor and Francis, 2005

Reference Books(s) :

1	B.H.Khan, "Non-conventional Energy Sources", Tata McGraw Hill Publishing Company, New Delhi, 2008
2	Gray, L. Johnson, “Wind Energy System”, Prentice Hall linc,1995.
3	Mukund R. Patel, ―Wind and Solar Power Systems‖, CRC Press LLC, second edition (15 July 2005)
4	Rai, G. D., ―Non Conventional Energy Sources‖, Khanna Publishers,18th edition 2017.
5	Rao S. Paruklekar, ―Energy Technology – Non-Conventional, Renewable and Conventional, Khanna Publishers, 3rd edition (2009).

Website Links:

1	https://onlinecourses.nptel.ac.in/noc21_ch11
2	https://niwe.res.in/department_sdt_itec.php
3	https://onlinecourses.nptel.ac.in/noc22_ee71

COs/POs & PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	-	-	-	-	3	-	-	-	-	2	1	1	-
CO 2	3	3	2	1	-	-	3	2	-	-	-	3	3	3	2
CO 3	3	3	2	1	-	-	3	2	-	-	-	3	3	3	2
CO 4	3	3	2	1	-	-	3	2	-	-	-	3	3	3	2
CO 5	3	3	3	2	2	-	3	2	-	-	-	3	3	3	3

Average	**3**	**3**	**2.25**	**1.25**	**2**	**-**	**3**	**2**	**-**	**-**	**-**	**2.8**	**2.6**	**2.6**	**2.25**

VERTICAL II - ELECTRIC VEHICLE TECHNOLOGY

Course Code	Course Title (Laboratory Course)	Category	L	T	P	C
EE23B21	**Wiring Harness Design Engineering**	**PE**	**0**	**0**	**6**	**3**

Objectives:

- To impart knowledge on electrical geometry in the 3-D EXPERIENCE platform and design of electrical physical systems.
- To provide knowledge on Routing of E-vehicle.
- To provide knowledge on design of electrical systems.
- To impart knowledge on Modeling, routing and battery pack.
- To inculcate knowledge on solid modeling, sweep and loft tools for implementation of E-Vehicle.

List of the Experiments

1. Study of 3-D Experience Software.
2. To create Sketch Profiles using Basic Sketch Tools.
3. To create Complex Profiles using Advanced Sketch Tools
4. To create Solid Model Using Sketch Based Features
5. Modification of Solid Model Using Refine/Edit & Transformation Features.
6. Solid Modeling using Sweep and Loft tools
7. Design of routing wires in E- Vehicle
8. Study of EV Powertrain elements & integration
9. 1-D modeling of powertrain architecture.
10. Study of Basic structure and functioning of a pouch battery pack.
11. Model dismantling process of a battery module in context of production line.
12. Model-based process plan from engineering design
13. Study of Multiphysics simulation.
14. Design of electrical physical systems - Electrical wire Harnessing.
15. Project work

Total Contact Hours:90

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

- Understand the electrical geometry in the 3-D EXPERIENCE platform and design of electrical physical systems.
- Understand routing of E-vehicle
- Understand modeling, routing and battery pack
- Understand and apply systematic approach to learn about usage of Electrical 3-D Systems Design.
- Understand solid modeling, sweep and loft tools for implementation of E-Vehicle.

SUGGESTED EVALUATION METHODS

- Experiment and Project based viva

Lab equipment required:

S. No	Name of the Equipment	Quantity Required
1	PC system	30
2	3D Experience Platform	25 user

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	2	3		3	3	3		2	3	3	2	3
CO 2	3	3	2	3	3		2	3	3		2	3	3	2	3
CO 3	3	3	3	3	3	2	2	3	3		2	3	3	3	3
CO 4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

CO 5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Average	**3**	**3**	**3**	**3**	**3**	**2.6**	**2.6**	**3**	**3**	**3**	**2.4**	**3**	**3**	**2.6**	**3**

Subject Code	**Subject Name (Theory Course)**	**Category**	**L**	**T**	**P**	**C**
EE23B11	**ELECTRIC VEHICLE ARCHITECTURE**	**PE**	**3**	**0**	**0**	**3**

Objectives:

- To learn the structure of EV, HEV
- To inculcate knowledge on the EV conversion components
- To impart knowledge on the details and specifications for EVs
- To acquire knowledge on the concepts of PHEV
- To explore to model and simulate DC motors

UNIT-I	**ELECTRIC VEHICLES**	**9**

Introduction to Electric Mobility - Definition for an Electric Vehicle-Advantages- disadvantages and challenges, EV History, and Evolution of EVs, Hybrid and Plug-In Hybrid Electric Vehicles, Near Future Trends For Electric Drive

UNIT-II	**EV CONVERSION COMPONENTS**	**9**

Electric Motors-Motor Controllers- step-up converter, three phase inverter, Batteries- Types of Battery Chargers - Wires, Switches, and Tools- Accessories- Instrumentation

UNIT-III	**III ELECTRIC VEHICLES**	**9**

e-cycle, Mountain Bike - Motorcycle- Electric Cars and Heavy Duty EVs -Details ,Specifications

UNIT-IV	**PLUG-IN HYBRID ELECTRIC VEHICLE**	**9**

Introduction-History-Comparison with electrical and hybrid electrical vehicle-Construction and working of PHEV-Block diagram and components-Charging mechanisms-Advantages of PHEVs

UNIT-V	**V MODELING AND SIMULATION OF BRUSHED-DC ELECTRIC MACHINERY**	**9**

Fundamentals of Operation – Introduction – Governing equations and modelling of Brushed DC-Motor – Shunt, Series and Compound – State model derivation – Matlab-Simulink Model of a DC Machine using state equations- separately excited, Shunt, Series and Compound motors- Simulation under no-load and loaded conditions-Simulation of smooth starting and speed control of DC motor

Total Contact Hours	**:**	**45**

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

- realize the History and Evolution of EVs, Hybrid and Plug-In Hybrid EVs
- describe the various EV components
- elucidate the details and concepts for the various EVs developed
- describe the concepts related in the Plug-In Hybrid Electric Vehicles
- Design model and simulate various types of DC machines

Text Book (s):

1. Mehrdad Ehsani, YiminGao, Sebastian E. Gay, Ali Emadi, 'Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design', CRC Press, 2004. Page 113-126 third edition 2018.
2. Build Your Own Electric Vehicle,Seth Leitman , Bob Brant, McGraw Hill, Third Edition 2013
3. Advanced Electric Drive Vehicles, Ali Emadi, CRC Press, First edition 2017

Reference Books(s) :

1. Dynamic Simulation of Electric Machinery using MATLAB, Chee Mun Ong, Prentice Hall, 1997
2. Electrical Machine Fundamentals with Numerical Simulation using MATLAB/ SIMULINK, Atif Iqbal,Shaikh Moinoddin, Bhimireddy Prathap Reddy, Wiley,2021
3. The Electric Vehicle Conversion Handbook: How to Convert Cars, Trucks, Motorcycles, and Bicycles -- Includes EV Components, Kits, and Project Vehicles Mark Warner,HP Books, 2011
4. Heavy-duty Electric Vehicles From Concept to Reality, SHASHANK ARORA, ALIREZA TASHAKORI ABKENAR, SHANTHA GAMINI JAYASINGHE,KARI TAMMI, Elsevier Science,2021
5. Electric Vehicles Modern Technologies and Trends, Nil Patel , Akash Kumar Bhoi,, Sanjeevikumar Padmanaban , Jens Bo Holm-Nielsen Springer,2020 page 53-73

6	Special Electrical Machines, K.Venktaratnam, university Press,2009
Web links :	
	https://www.iea.org/reports/electric-vehicles
	https://www.edfenergy.com/electric-cars/costs
Suggested Activities: To fabricate a e-cycle kit and test it	
Suggested Evaluation methods: weightage to be given to practical work on e-vehicles	

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	-	-	-	-	3	-	-	-	-	2	1	1	-
CO 2	3	3	2	1	-	-	3	2	-	-	-	3	3	3	2
CO 3	3	3	2	1	-	-	3	2	-	-	-	3	3	3	2
CO 4	3	3	2	1	-	-	3	2	-	-	-	3	3	3	2
CO 5	3	3	3	2	2	-	3	2	-	-	-	3	3	3	3
Average	**3**	**3**	**2.25**	**1.25**	**2**	**-**	**3**	**2**	**-**	**-**	**-**	**2.8**	**2.6**	**2.6**	**2.25**

Subject Code	**Subject Name(Lab Oriented Theory Course)**	**Category**	**L**	**T**	**P**	**C**
EE23B31	**DESIGN OF ELECTRIC VEHICLE CHARGING SYSTEM**	**PC**	**2**	**0**	**2**	**3**

Objectives:

- To impart knowledge on charging station and standards
- To provide knowledge on Batteries and BMS
- To learn the concepts of power converters in EV charging
- To teach the wireless power transfer technique in EV charging
- To learn renewable energy based EV charging schemes

UNIT-I	**CHARGING STATIONS AND STANDARDS**	**6**

Introduction-Charging technologies- Conductive charging- EV charging infrastructure - Inductive charging- Need for inductive charging of EV- Modes and operating principle- Static and dynamic charging- Bidirectional power flow, International standards and regulations

UNIT-II	**INTRODUCTION TO BATTERIES AND BMS**	**6**

Types of Batteries - Equivalent circuit model of Li - Ion Battery- Charging and Discharging Characteristics of Batteries – Internal Resistance – Series and Parallel connection of Batteries – Battery Management System (BMS)- Overview - Architecture – BMS Sensing – Estimation of SoC - SoH, SoF and DoD

UNIT-III	**POWER ELECTRONICS FOR EV CHARGING**	**6**

Layouts of EV Battery Charging Systems-AC charging-DC charging systems- Power Electronic Converters for EV Battery Charging- Bidirectional DC–DC Converters- Non-isolated DC–DC bidirectional converter topologies- Half-bridge bidirectional converter- Need for power factor correction- AC–DC converter with boost PFC circuit, with bridge and without bridge circuit

UNIT-IV	**WIRELESS POWER TRANSFER**	**6**

Introduction - Inductive, Magnetic Resonance, Capacitive types. Wireless Chargers for Electric Vehicles - Types of Electric Vehicles - Battery Technology in EVs -Charging Modes in EVs - Benefits of WPT - WPT Operation Modes - Standards for EV Wireless Chargers, SAE J2954 , IEC 61980, ISO 19363.

UNIT-V	**EV CHARGING USING RENEWABLE AND STORAGE SYSTEMS**	**6**

Introduction - EV charger topologies - EV charging/discharging strategies - Integration of EV charging-home solar PV system - Operation modes of EVC-HSP system - Control strategy of EVC-HSP system - fast-charging infrastructure with solar PV and energy storage.

Contact Hours	**:**	**30**

List of Experiments

1	Simulation of Bidirectional DC-DC Buck Converter based charging system.
2	Simulation of primary battery management systems

3	Simulation of boost converter based power factor correction (with bridge rectifier) in EV charging system.
4	Simulation of boost converter based power factor correction (without bridge rectifier) in EV charging system.
5	Simulation of the charge system of the given batteries for the specified time period through inductive coupling
6	Simulation of the charge system of the given batteries through the energy extracted from the Photovoltaic cell.
7	Simulation of the charge system of the given batteries through the energy extracted from the PMSG.

Contact Hours	**:**	**15**
Total Contact Hours	**:**	**45**

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

- comprehend the structure of charging station and standards
- analyze the structure of Batteries and relevant BMS parameters
- apply the concepts of power converters in EV charging
- apply the wireless power transfer technique in EV charging
- analyze the renewable based EV charging schemes

Suggested Activities

- Do the internet survey and make a list of leading manufactures of the PLC, SCADA, with their brand name.
- Read an operating manual of the PLCs of reputed Manufactures.
- Download animated videos from the internet for any theory topic and make presentation on it.
- Prepare a list of available analog input /output devices, digital input /output devices available in the market.
- Prepare report on steps to be followed to configure available SCADA software.

Suggested Evaluation Methods

- Project Based Evaluation

Text Book (s):

1	Mobile Electric Vehicles Online Charging and Discharging, Miao Wang Ran Zhang Xuemin (Sherman) Shen, Springer 2016
2	Nil Patel, Akash Kumar Bhoi, Sanjeevikumar Padmanaban,Jens Bo Holm-Nielsen, Electric Vehicles Modern Technologies and Trends. Springer Publisher 2020
3	A Triviño-Cabrera ,José M. González-González,José A. Aguado, Wireless Power Transfer for Electric Vehicles: Foundations and Design Approach, Springer Publisher 2019

Reference Books(s) / Web links:

1	Cable Based and Wireless Charging Systems for Electric Vehicles, Technology and control, management and grid integration, Rajiv Singh, Sanjeevikumar Padmanaban, Sanjeet Dwivedi, Marta Molinas and Frede Blaabjerg, IET 2021
2	Electric and Hybrid Electric Vehicles, James D Halderman, Pearson, 2022
3	Handbook of Automotive Power Electronics and Motor Drives, Ali Emadi, Taylor & Francis, 2005.

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	2	2	-	-	-	-	3	3	3	-	1	1	3	3
CO 2	3	3	3	-	-	-	-	2	3	1	-	3	3	2	2
CO 3	3	3	2	-	-	-	-	1	2	2	-	-	1	1	1
CO 4	2	2	2	-	-	-	-	3	2	3	-	1	2	2	3
CO 5	3	1	3	-	-	-	-	3	3	2	-	2	2	2	2
Average	2.8	2.2	2.4					2.4	2.6	2.2		1.75	1.8	2	2.2

Course Code	Course Title(Laboratory Integrated Theory Course)	Category	L	T	P	C
EE23B32	**POWER CONVERTERS AND MOTORS FOR ELECTRIC VEHICLES**	**PC**	**2**	**0**	**2**	**3**

Objectives:

- To familiarise the different types of DC - DC Power Converters used in Electric Vehicles

●	To provide knowledge on different types of Inverters used in Electric Vehicles
●	To inculcate knowledge on the construction, principle of operation and design of Induction and PMBLDC Motors
●	To impart knowledge on construction, principle of operation and design of Synchronous Reluctance Motor and Permanent Magnet Synchronous Motor
●	To learn the construction, principle of operation and design of Switched Reluctance Motor and Axial Flux Motor

UNIT-I	**POWER CONVERTERS FOR ELECTRIC VEHICLES**	**6**
Introduction to Components of Electric Vehicles, Non-Isolated DC-DC Converter: Boost Converter, Buck Converter, Buck-Boost Converter, Cascading of Converters, Isolated DC- DC Converters: Flyback Converter, Forward Converter- Modes of Operation and Analysis.		
UNIT-II	**INVERTERS FOR ELECTRIC VEHICLES**	6
Introduction to H Bridge Inverter, Three Phase Voltage and Current source inverters - operation and analysis. Modulation techniques for VSI – SPWM, SVPWM.		
UNIT-III	**INDUCTION MOTOR AND PMBLDC MOTOR**	6
Induction motor - Construction and operation, torque and power equation, Torque-Speed Characteristics, Braking methods. PMBLDC Motor - Constructional features, Operating principle, EMF and torque developed, Torque-Speed Characteristics.		
UNIT-IV	**PERMANENT MAGNET SYNCHRONOUS MOTOR**	6
PMSM Motor – Construction and types of PMSM - EMF and torque developed, Torque - Speed Characteristics Phasor diagram, Braking methods- Vector Control		
UNIT-V	**AXIAL FLUX MOTOR**	6
Axial Flux Motor - Constructional features, Principle of operation, Torque developed and Speed Control. Introduction to Raxial motor.		

Contact Hours	**:**	**30**

List of Experiments

1	Simulation of Buck converters with R and RL loads
2	Simulation of Boost converters with R, RL and RLE loads
3	Simulation of SPWM inverter with Induction Motor load
4	Design of PMSM Motor using MATLAB
5	Study of PMBLDC motor/PMSM motor using ‘Motor solve’ - software

Contact Hours	**:**	**15**
Total Contact Hours	**:**	**45**

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

•	Choose and design the appropriate DC - DC Power Converter and Inverter for Electric Vehicle applications
•	Design and analyse the Induction Motor
•	Design and analyse the Permanent Magnet Synchronous Motor
•	Design and analyse PMBLDC motor
•	Perform simulation of different types of power converters and motors used in Electric Vehicles using MATLAB.

Suggested Activities

- Mini projects can be done in Power Converters using Controllers
- Simulation of Converters can be done by various Tools

Suggested Evaluation Methods

- Assignment
- Assessment

Text Book (s):

1	Jananardanan, Special electrical machines, Prentice hall India,2013
2	Philip T Krein, Elements of Power Electronics, Oxford university press,2003
3	Venkataratnam, Special electrical machines, Oxford university press,2021

Reference Books(s) :

1	M.H.Rashid, Power electronics, Pearson,2017

2	Electrical Machine Fundamentals with Numerical Simulation using MATLAB/SIMULINK, Atif Iqbal, Shaikh Moinoddin, Bhimireddy Prathap Reddy, Wiley,2021
3	Theodore wildi, Electrical machines and drives,pearson,2015
4	Electric and Hybrid Vehicles Design fundamentals, Iqbal Husain, Taylor and Francis Third edition 2021.
Web links :	
1	https://onlinecourses.nptel.ac.in/noc23_ee38/preview
2	https://onlinecourses.nptel.ac.in/noc20_ee18/preview

Lab Equipments Required

Matlab

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	3	3	2	2	1	3	2	3	3	3	2	3
CO 2	3	3	3	3	3	2	2	1	3	2	3	3	3	2	3
CO 3	3	3	3	3	3	2	2	1	3	2	3	3	3	2	3
CO 4	3	3	3	3	3	2	2	1	3	2	3	3	3	2	3
CO 5	3	3	3	3	3	2	2	1	3	2	3	3	3	2	3
Average	**3**	**3**	**3**	**3**	**3**	**2**	**2**	1	**3**	**2**	**3**	**3**	**3**	**2**	**3**

Subject Code	**Subject Name(Lab Oriented Theory Course)**	**Category**	**L**	**T**	**P**	**C**
EE23B33	**CONTROL OF ELECTRIC VEHICLES**	**PC**	**2**	**0**	**2**	**3**

bjectives:

- To impart knowledge on different control schemes applied to Induction Motors.
- To provide knowledge on different methods of control of synchronous reluctance motors.
- To get familiarized with the different control techniques for PMBLDC motor.
- To inculcate knowledge on the various control schemes applied to permanent magnet synchronous motors.
- To teach the different control methods applicable for axial flux switched reluctance motors

UNIT-I	**CONTROL OF POWER CONVERTERS**	**6**

Need for Closed Loop Control – Voltage Mode Control (VMC) – Current Mode Control (CMC) – Advantages of CMC over VMC –Cascade Control Strategy – Condition for implementing Cascade Control Strategy - Introduction to fixed and variable frequency PWM methods.

UNIT-II	**CONTROL OF INDUCTION MOTOR**	**6**

d-q Model, Scalar Control - v/f Control, Voltage Fed Inverter Control, Current Fed Inverter Control, Direct torque control - Control system model of EV driven by induction motor.

UNIT-III	**CONTROL OF PERMANENT MAGNET BRUSHLESS DC MOTORS**	**6**

Control of PMBLDC Motor using 3-pulse Converter and 6 pulse Inverter, Structure of controller, Closed loop Current Mode Control - Microcontroller based implementation of PMBLDC Drive. Control of E-bike

UNIT-IV	**CONTROL OF PERMANENT MAGNET SYNCHRONOUS MOTORS**	**6**

Self-control, v/f control, Direct Torque control, Vector control, Sensorless control, Microcontroller based PMSM Drive.

UNIT-V	**CONTROL OF AXIAL FLUX MOTORS**	**6**

Current Control Schemes- Hysteresis and PWM control - Embedded control of axial flux motor.

	Contact Hours	**: 30**

List of Experiments

1	Testing of v/f controller for Induction motor
2	Speed control of PMDC motor
3	Speed control of BLDC motor
4	Speed of control of SRM motor

5	Testing of PMSM motor			
		Lab Contact Hours	**:**	**15**
		Total Contact Hours	**:**	**45**
Course Outcomes: On completion of the course, the students will be able to				
●	To determine the appropriate control scheme for the speed control of Induction Motors			
●	To select the suitable control scheme for the control of PMBLDC motor			
●	To realize the appropriate control scheme for the control of permanent magnet synchronous motors			
●	To apply the suitable control method for the speed control of switched reluctance motors			
●	To realize the speed control of various motors used in Electric Vehicles using Matlab/Simulink software tool.			
Suggested Activities ●Seminars ●Guest Lectures				
Suggested Evaluation Methods ● Assignments ● Assessments				
Text Book (s):				
1	Kenjo, T and Nagamori, S "Permanent Magnet and brushless DC motors ", Clarendon Press, Oxford, 1989.			
2	R.Krishnan, "Electric Motor Drives – Modeling, Analysis and Control", Pearson Education India Pvt. Ltd., 2015.			
3	R.Krishnan, "Switched Reluctance Motor Drives: Modeling, Simulation, Analysis, Design and Applications" CRC Press, 2017.			
Reference Book (s):				
1	Miller, T.J.E. "Brushless permanent magnet and reluctance motor drives ", Clarendon Press, Oxford, 1989.			
2	B.K. Bose, "Modern Power Electronics & AC drives", Pearson Education India Pvt. Ltd., New Delhi, 2012.			
3	VedamSubrahmanyam, "Electric Drives: Concepts & Applications", 2nd Edition Tata Mc Graw Hill Publishing Co Ltd,2010			
Web links				
1	https://cdn.intechopen.com/pdfs/12061/InTech-Control_of_electric_vehicle.pdf			

Lab Equipments Required

	Name of the Equipment	Quantity Required
1	Personal computers (Pentium-IV, 80GB, 512 MBRAM)	25
2	Printer laser	1
3	Server (Pentium IV, 80GB, 1GBRAM) (High Speed Processor)	1
4	Software: MATLAB software	25

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	-	-	-	-	3	-	-	-	-	2	1	1	-
CO 2	3	3	2	1	-	-	3	2	-	-	-	3	3	3	2
CO 3	3	3	2	1	-	-	3	2	-	-	-	3	3	3	2
CO 4	3	3	2	1	-	-	3	2	-	-	-	3	3	3	2
CO 5	3	3	3	2	2	-	3	2	-	-	-	3	3	3	3
Average	**3**	**3**	**2.25**	**1.25**	**2**	**-**	**3**	**2**	**-**	**-**	**-**	**2.8**	**2.6**	**2.6**	**2.25**

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
EE23B12	**ELECTRIC VEHICLES AND POWER MANAGEMENT**	**PE**	**3**	**0**	**0**	**3**

Objectives:		
● To understand the concept of electric vehicles and its operations		
● To present an overview of Electric Vehicle (EV), Hybrid Electric vehicle (HEV) and theirarchitecture		
● To understand the need of power electronics to control motor drive		
● To understand the need for energy storage in hybrid vehicles		
● To provide knowledge about various possible energy storage technologies that can beused in electric vehicles		
UNIT-I	**ELECTRIC VEHICLES AND VEHICLE MECHANICS**	**9**
Conventional Vehicles: Internal combustion Engines – Comparisons of EV with internal combustion Engine vehicles-Fundamentals of vehicle mechanics. Working principle, Engine Operation Characteristics, Emission Control. EV vehicles: EV system – Configurations of EVs – Components of EV – Recent EVs and HEVs – EVs advantages – EVs market -Engine ratings.		
UNIT-II	**ARCHITECTURE OF EV's AND POWER TRAIN COMPONENTS**	**9**
Architecture of EV's and HEV's – Concept of Hybrid Electric drive, Types of Hybrids, Plug-n Hybrid Electric Vehicles (PHEV)- Power train components and sizing, Gears, Clutches, Transmission and Brakes. Fuel Cell Electric Vehicles (FCEVs), Comparison of Different Vehicle Specifications.		
UNIT-III	POWER ELECTRONICS AND MOTOR DRIVES	9
Electric drive components – Power electronic switches- four quadrant operation of DC drives – Induction motor and permanent magnet synchronous motor-based Field Oriented Control (FOC) – Switched reluctance motor (SRM) drives- EV motor sizing. Configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives.		
UNIT-IV	**BATTERY ENERGY STORAGE SYSTEM AND POWER CONVERTER TOPOLOGIES**	**9**
Battery Basics- Different types- Battery Parameters-Battery life & safety impacts -Battery Modelling-Design of battery for large vehicles – Constant Current Constant Voltage (CCCV) Charging of batteries. Chemical & structure material properties for cell safety and battery design, battery testing, limitations for transport and storage of cells and batteries, Recycling, disposal and second use of batteries. Battery Leakage: gas generation in batteries, leakage path, leakage rates Power converter topology, Grid and Photovoltaic (PV) System for EV/PHEV Charging, Design of DC/DC Converters and DC/AC Inverters for Grid/PV..		
UNIT-V	**ALTERNATIVE ENERGY STORAGE SYSTEMS**	**9**
Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its modeling, SOC, Introduction to fuel cell – Types, Operation and characteristics- proton exchange membrane (PEM) fuel cell for E-mobility– hydrogen storage systems –Super capacitors for transportation applications.		
		Total Contact Hours: 45
Course Outcomes: At the end of this course, the students will demonstrate the ability to		
● Understand the concept of electric vehicle and energy storage systems.		
● Describe the working and components of Electric Vehicle and Hybrid Electric Vehicle		
● Know the principles of power converters and electrical drives		
● Illustrate the operation of storage systems such as battery and super capacitors		
● Analyze the various energy storage systems based on fuel cells and hydrogen storage		
SUGGESTED ACTIVITIES ● Activity Based Learning		
Text Book(s):		
1. Iqbal Hussain, "Electric and Hybrid Vehicles: Design Fundamentals, Second Edition**"** CRCPress, Taylor & Francis Group, Second Edition (2011).		
2. Ali Emadi, Mehrdad Ehsani, John M.Miller, "Vehicular Electric Power Systems", SpecialIndian Edition, Marcel dekker, Inc 2010.		
3. Mehrdad Ehsani, YiminGao, Sebastian E. Gay, Ali Emadi, 'Modern Electric, Hybrid Electricand Fuel Cell Vehicles: Fundamentals, Theory and Design', CRC Press, 2004.		
4. M. Ehsani, Y. Gao, S. E. Gay and A. Emadi, 'Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design', CRC Press, 2004.		
5.		

Reference Books(s) / Web links:
● C.C. Chan and K.T. Chau, 'Modern Electric Vehicle Technology', OXFORD UniversityPress, 2001.
● Wie Liu, “Hybrid Electric Vehicle System Modeling and Control”,Second Edition, John Wiley& Sons, 2017.
● NPTEL for fundamentals of electric vehicle : https://archive.nptel.ac.in/courses/108/106/108106170/
● 1. C. Mi, M. A. Masrur and D. W. Gao, ‘Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives’, John Wiley & Sons, 2011. 2.. 3. Larminie, James, and John Lowry, ‘Electric Vehicle Technology Explained’ John Wiley and Sons, 2012.
● S. Onori, L. Serrao and G. Rizzoni, ‘Hybrid Electric Vehicles: Energy Management Strategies’, Springer, 2015
● Tariq Muneer and Irene Illescas García, ‘The automobile, In Electric Vehicles: Prospects and Challenges’, Elsevier, 2017. 5.
● Sheldon S. Williamson, ‘Energy Management Strategies for Electric and Plug–in Hybrid Electric Vehicles’, Springer, 2013. 6. Gregory L. Plett, ‘Battery Management systems’, ARTECH House, London, 2016.
WEB RESOURCES
1. https://nptel.ac.in/courses/108106170 2. https://onlinecourses.nptel.ac.in/noc22_ee53 3. https://onlinecourses.nptel.ac.in/noc21_ee112

COs/POs&PSOs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO 1	3	3	-	-	-	-	3	-	-	-	-	2	1	1	-
CO 2	3	3	2	1	-	-	3	2	-	-	-	3	3	3	2
CO 3	3	3	2	1	-	-	3	2	-	-	-	3	3	3	2
CO 4	3	3	2	1	-	-	3	2	-	-	-	3	3	3	2
CO 5	3	3	3	2	2	-	3	2	-	-	-	3	3	3	3
Average	**3**	**3**	**2.25**	**1.25**	**2**	**-**	**3**	**2**	**-**	**-**	**-**	**2.8**	**2.6**	**2.6**	**2.25**

Subject Code	**Subject Name(Theory Course)**	**Category**	**L**	**T**	**P**	**C**
EE23B13	**GRID INTEGRATION OF ELECTRIC VEHICLES**	**PC**	**3**	**0**	**0**	**3**

Objectives:	
●	To acquire knowledge on energy exchange between storage element and power grid.
●	To provide knowledge on the benefits of V2G
●	To learn the challenges in V2G integrated power system
●	To learn the impacts of EV and V2G on the power grid
●	To familiarize the management of EVs

UNIT-I	**INTRODUCTION TO G2V AND V2G**	**9**
Introduction to power grid and smart grid. Definition of G2V and V2G - History and Development of V2G. Incorporating V2G for EVs, Types of storage: Short-term and Long-Term.		
UNIT-II	**BENEFITS OF V2G**	**9**
Benefits of V2G. Technical Benefits: Storage Superiority and Grid Efficiency - Economic Benefits: EV Owners and Societal Savings - Environment and Health Benefits: Sustainability in Electricity and Transport.		
UNIT-III	**CHALLENGES IN V2G**	**9**
Technical Challenges- Effect of Battery Degradation, Conversion Efficiency of EV Charger. The Economic and Business Challenges of V2G - Evolving Nature of V2G Costs and Benefits. Introduction to Regulatory Challenges and Frameworks.		
UNIT-IV	**IMPACT OF EV AND V2G ON POWER GRID**	**9**

Impact of Electric Vehicles on power quality issues - Load management using Renewable Energy Sources and EVs. Impacts of EVs on environment.				
UNIT-V	**MANAGEMENT OF EVs**			**9**
Introduction to Machine to Machine (M2M) communication- M2M in distributed energy management systems - M2M communication for EVs - Overview of cloud-based energy management service for Electric vehicles - Data loggers for EVs. - Charging Station Discovery Selection and Status Server (CDSSS).				
		Total Contact Hours	**:**	**45**
Course Outcomes: On completion of the course, the students will be able to				
●	analyse the methods of energy exchange between storage element to power system grid.			
●	realise the benefits of V2G			
●	analyse the technical and regulatory challenges related to V2G			
●	comprehend the impact of EV and V2G on power grid			
●	realize the concept of management of EVs.			
Text Book (s):				
1	Advanced Electric Drive Vehicles, Ali Emadi, CRC Press 2017			
2	Plug In Electric Vehicles in Smart Grids, Charging Strategies, Sumedha Rajakaruna , Farhad Shahnia and Arindam Ghosh,Springer,2015			
3	ICT for Electric Vehicle Integration with the Smart Grid, Nand Kishor; Jesus Fraile-Ardanuy, IET 2020			
Reference Books(s) / Web links:				
1	Vehicle-to-Grid: Linking Electric Vehicles to the Smart Grid, Junwei Lu and Jahangir Hossain, IET 2015			
2	Lance Noel · Gerardo Zarazua de Rubens Johannes Kester · Benjamin K. Sovacool, Vehicle-to-Grid A Sociotechnical Transition Beyond Electric Mobility, 2019			
3	Emadi, A. (Ed.), Miller, J., Ehsani, M., "Vehicular Electric Power Systems" Boca Raton, CRC Press, 2003 .			
4	https://www.iec.ch/technical-committees-and-subcommittees#tclist			
Suggested Activities • Technical quiz • Industrial visit to power station • Simulation models onn V2G technologies				
Suggested Evaluation Methods CAT Exam , Assignments				

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	3	3	3	3	1	1	2	3	3	3	3	3
CO 2	3	3	3	3	3	3	3	1	1	2	3	3	3	3	3
CO 3	3	3	3	3	3	3	3	1	1	2	3	3	3	3	3
CO 4	3	3	3	3	3	3	3	1	1	2	3	3	3	3	3
CO 5	3	3	3	3	3	3	3	1	1	2	3	3	3	3	3
Average	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**1**	**1**	**2**	**3**	**3**	**3**	**3**	**3**

VERTICAL III- ADVANCED POWER ENGINEERING

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
EE23C11	**HIGH VOLTAGE DIRECT CURRENT TRANSMISSION**	**PE**	**3**	**0**	**0**	**3**

Objectives:		
●	To understand the concept, planning of DC power transmission and comparison with AC Power transmission.	
●	To provide knowledge on the analysis of HVDC converters.	
●	To study about the HVDC system control.	
●	To impart knowledge on harmonics and design of filters.	
●	To learn the model and analysis the DC system under study state.	
UNIT-I	**INTRODUCTION**	
DC Power transmission technology – Comparison of AC and DC transmission – Planning and Application of DC transmission – Description of HVDC transmission system – Modern trends in HVDC technology – DC breakers – Types and applications of HVDC links and MTDC systems. Case study on HVDC systems in India.		9
UNIT-II	**ANALYSIS OF HVDC CONVERTERS**	
Voltage Source Converters (VSC) – Analysis of Graetz circuit with and without overlap – Pulse number – Choice of converter configuration – Converter bridge characteristics – Analysis of a 12 pulse converters – Analysis of VSC topologies and firing schemes.		9
UNIT-III	**CONVERTER AND HVDC SYSTEM CONTROL**	
Principles of DC link control and converter control characteristics – System control hierarchy – Firing angle control – Current and extinction angle control – Starting and stopping of DC link – Power control – Higher level controllers – Control of VSC based HVDC link - Converter malfunctioning.		9
UNIT-IV	**REACTIVE POWER AND HARMONICS CONTROL**	
Reactive power requirements in steady state – Sources of reactive power – SVC and STATCOM Harmonics in HVDC - characteristics and uncharacteristic harmonics, Calculation of voltage and current harmonics -harmonic filters – active and passive filters - Ratings of filter components and protection of Filters.		9
UNIT-V	**POWER FLOW ANALYSIS IN AC/DC SYSTEMS**	
Per unit system for DC quantities – DC system model – Inclusion of constraints – Power flow analysis – Solution of AC/DC power flow-Simultaneous method- Sequential method-–Protection Systems in HVDC Substation-HVDC Simulator.		9
	Total Contact Hours : 45	
Course Outcomes:		
●	Realize the concept, planning of DC power transmission and comparison with Power transmission.	
●	Formulate and Solve mathematical related to HVDC converters.	
●	Develop models and concept of HVDC system control	
●	Analyze the harmonics and design of filters.	
●	Understand DC system under steady state	
Suggested Activities		
●	Group discussion on applications	
●	Exposure through industrial visit	
Suggested Evaluation Methods		
●	Seminars	
●	Group Assignments	
Text Book(s):		
1	K.R. Padiyar, "HVDC Power Transmission System", New Age Intl, third edition, 2015.	
2	Edward Wilson Kimbark, "Direct Current Transmission", Vol. I, Wiley interscience, New York, London, Sydney, 1971.	
3	Rakosh Das Begamudre, "Extra High Voltage AC Transmission Engineering", NewAge International (P) Ltd., New Delhi, 1990	
Reference Books(s):		
1	Dragan Jovcic, Khaled Ahmed, "High Voltage Direct Current Transmission: Converters, Systems and DC Grids", Wiley Publishers, first edition, 2015.	
2	Colin Adamson and Hingorani N G, "High Voltage Direct Current Power Transmission", Garraway Limited, London, 1960	

3	S. Kamkshaiah, V Kamraju, "HVDC transmission", Tata McGraw Hill, second edition, 2021.
4	S.Rao, "EHV-AC, HVDC Transmission and Distribution Engineering", Khanna Publishers,3rd Edition, 2012
5	NPTEL: https://nptel.ac.in/courses/108106160.
Web links:	
	https://nptel.ac.in/courses/108104013

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	2	-	3	1	-	-	-	2	2	3	3	1
CO 2	3	3	3	2	-	3	1	-	-	-	2	2	3	3	1
CO 3	3	3	3	2	-	3	1	-	-	-	2	2	3	3	1
CO 4	3	3	3	2	-	3	1	-	-	-	2	2	3	3	1
CO 5	3	3	3	2	-	3	1	-	-	-	2	2	3	3	1
Average	**3**	**3**	**3**	**2**	**-**	**3**	**1**	**-**	**-**	**-**	**2**	**2**	**3**	**3**	**1**

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
EE23C12	**POWER SYSTEM TRANSIENTS**	**PE**	**3**	**0**	**0**	**3**

Objectives:

- To learn the importance of study of transients, different types of power system transients and its effect on power system.
- To familiarize the over voltages due to switching transients by resistance, load and capacitive switching.
- To get knowledge on the over voltages due to lightning transients, protection of power system from lightning.
- To expose the transients using travelling wave equations on transmission line and repeated reflection by bewely's lattice diagram.
- To introduce the transient in integrated power system and transients computation using Electro Magnetic Transients Program (EMTP).

UNIT-I INTRODUCTION 9

Introduction of transients. Source and Causes of transients. Different types of transients. Basic transforms of the RLC circuits, Series and parallel circuit transients. Effect of transients on power systems. Importance of study of transients in system planning.

UNIT-II SWITCHING OVERVOLTAGES 9

Circuit closing transients (RL circuit transient with sine wave excitation), Types of Switching: Resistance switching, Load switching, Capacitance switching**.** Normal and abnormal switching transients. Ferro resonance. Generation of switching surge voltage.

UNIT-III LIGHTNING OVERVOLTAGES 9

Lightning: Physical phenomena of lightning. Interaction between lightning and power system. Factors contributing to good line design, Conventional lightning protection schemes for transmission lines and terminal equipments, Overvoltage protective devices. Insulation co-ordination, High voltage testing of electrical power apparatus as per international and Indian standards.

UNIT-IV COMPUTATION OF TRANSIENTS 9

Travelling wave concept: Bewely's lattice diagram. Reflection, Refraction and behavior of travelling waves at the line terminations. Computation of transients: Transient response of systems with series and shunt lumped parameters and distributed lines (Wave Equation). Introduction to EMTP for transient computation. Principle of digital computation of transients.

UNIT-V TRANSIENTS IN INTEGRATED POWER SYSTEM 9

Causes of power frequency over voltage. Switching surges on integrated power system. Voltage transients on closing and reclosing of lines. Line dropping and load rejection. Short line or kilometric fault. Case Studies: line with short and open end, line terminated with R, L and C.

Total Contact Hours : 45

Course Outcomes:

At the end of the course the student will be able to

- understand the importance of transients, and its effects on power system.
- analyze the over voltages due to switching transients
- know about the over voltages due to lightning transients and protection against it
- evaluate the transients using travelling wave equations and bewely's lattice diagram.

●	realize the transient in integrated power system and their computation using Electro Magnetic Transients Program.
Text Book(s):	
1	Allan Greenwood, "Electrical Transients in Power System", Wiley & Sons Inc. New York, 2012.
2	Naidu M S and Kamaraju V, "High Voltage Engineering", Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2004.
3	R. Ramanujam, "Computational Electromagnetic Transients: Modelling, Solution Methods and Simulation", I.K. International Publishing House Pvt. Ltd, New Delhi -110 016, ISBN 978-93-82332-74-9, 2014.
Reference Books(s) / Web links:	
1	Rakosh Das Begamudre, "Extra High Voltage AC Transmission Engineering", (Second edition) Newage International (P) Ltd., New Delhi, 2006.
2	Klaus Ragaller, "Surges in High Voltage Networks", Plenum Press, New York, 1980.
3	IEEE Guide for safety in AC substation grounding IEEE Standard 80-2000.
4	Working Group 33/13-09 (1988), "Very fast transient phenomena associated with Gas Insulated System", CIGRE, 33-13, pp. 1-20.
5	https://ieeexplore.ieee.org/document/7452713

COs/POs&PSOs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO 1	3	1		2	1	2	2					1	3	3	1
CO 2	3	3		3	2	3	2					1	3	3	1
CO 3	3	3		3	2	3	2					1	3	3	1
CO 4	3	3		3	2	3	2					1	3	3	1
CO 5	3	3		3	2	3	2					1	3	3	1
Average	**3**	**2.6**		**2.8**	**1.8**	**2.8**	**2**					**1**	**3**	**3**	**1**

Subject Code	**Subject Name (Theory course)**	**Category**	**L**	**T**	**P**	**C**
EE23C13	**FLEXIBLE AC TRANSMISSION SYSTEMS**	**PE**	3	0	0	3

Objectives:

- To learn the reactive power control techniques
- To impart knowledge on static VAR compensators
- To provide knowledge on thyristor controlled series capacitors
- To get knowledge on voltage source converter based FACTS controllers
- To provide knowledge on application of FACTS controllers

UNIT-I	**INTRODUCTION**	9

Reactive power control in AC transmission line – Uncompensated Transmission line - Load and System Compensation - Passive reactive power compensation: Effect of series and shunt compensation at the mid-point of the line on power transfer - Need for FACTS controllers - Types of FACTS controllers.

UNIT-II	**STATIC VAR COMPENSATOR (SVC)**	9

Overview of different types of SVC - Characteristics of SVC - Voltage control by SVC – Advantages of slope in dynamic characteristics – Influence of SVC on system voltage – Design of SVC voltage regulator –Modelling of SVC for power flow and fast transient stability studies.

UNIT-III	**THYRISTOR CONTROLLED SERIES CAPACITOR (TCSC)**	9

Concepts of Controlled Series Compensation – Operation of TCSC – Different modes of operation of TCSC – Modelling of TCSC – Variable reluctance and Transient Stability model - Modelling of TCSC for load flow studies – Modelling of TCSC for stability studies.

UNIT-IV	**VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS**	9

Static synchronous compensator (STATCOM): Principle of operation and V-I Characteristics of STATCOM - Static synchronous series compensator (SSSC): Operation of SSSC - Power flow control with STATCOM and SSSC –Unified power flow controller (UPFC): Operation of UPFC – Different modes of UPFC – Interline power flow controller (IPFC) – Dynamic voltage restorer (DVR).

UNIT-V	**APPLICATION OF FACTS CONTROLLERS**	9

Applications: SVC- Enhancement of transient stability – Steady state power transfer – Enhancement of power system damping. TCSC - Improvement of the system stability limit – Enhancement of system damping – Prevention of Voltage Instability. STATCOM - Steady state power transfer - Enhancement of transient stability – Case Study: Role of FACTS device in renewable energy integrated power system.			
	Total Contact Hours	**:**	**45**
Course Outcomes: At the end of the course the student will be able to			
●	Realize the reactive power control techniques		
●	Understand the Static VAR compensators		
●	Know about the operation, modelling of TCSC and GCSC		
●	Realize the STATCOM, SSSC, UPFC and IPFC and their modelling		
●	Understand the application of FACTS controllers.		
Suggested Activities			
●	Group discussion on applications		
●	Exposure through industrial visit		
Suggested Evaluation Methods			
●	Seminars		
●	Group Assignments		
Text Book (s):			
1	R.MohanMathur, Rajiv K.Varma, "Thyristor – Based Facts Controllers for Electrical TransmissionSystems", IEEE press and John Wiley & Sons, Inc, 2002.		
2	Narain G. Hingorani, "Understanding FACTS -Concepts and Technology of Flexible ACTransmission Systems", Standard Publishers Distributors, Delhi- 110 006, 2011.		
3	K.R.Padiyar, "FACTS Controllers in Power Transmission and Distribution", New Age International (P) Limited, Publishers, New Delhi, 2009.		
Reference Books(s):			
1	A.T.John, "Flexible A.C. Transmission Systems", Institution of Electrical and Electronic Engineers (IEEE), 2009.		
2	V.K.Sood, "HVDC and FACTS controllers – Applications of Static Converters in Power System", APRIL 2004 , Kluwer Academic Publishers, 2004.		
3	Xiao – Ping Zang, Christian Rehtanz and Bikash Pal, "Flexible AC Transmission System: Modelling and Control" Springer, 2012.		
4	Emmanuel D. Rogdakis, Irene P. Koronaki, "Recent Advances in Renewable Energy", Bentham Science Publishers, 2018.		
5	Nishant Kumar, "Superconducting Magnetic Energy Storage (SMES) System", IEEE, 2015.		
6	AminMohammad Saberian, Payam Farzan, "Role of FACTS Devices in Improving Penetration of Renewable Energy", IEEE, 2013.		
Web links:			
	https://archive.nptel.ac.in/courses/108/107/108107114/		

COs/POs&PSOs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO 1	2	1	2	3	1	1	1			1	1	3	3	3	2
CO 2	2	1	2	3	1	1	1			1	1	2	2	2	2
CO 3	2	1	2	3	1	1	1			1	1	1	1	1	1
CO 4	2	2	2	2	1	1	1			1	1	2	2	2	2
CO 5	3	1	2	2	1	1	1			1	1	2	3	2	2
Average	**2.2**	**1.2**	**2**	**2.6**	**1**	**1**	**1**			**1**	**1**	**2**	**2.2**	**2**	**1.8**

Subject Code	**Subject Name (Theory course)**	**Category**	**L**	**T**	**P**	**C**
EE23C14	**RESTRUCTURED POWER SYSTEMS**	**PE**	**3**	**0**	**0**	**3**

Objectives:		
✓	To introduce the restructuring of power industry and market models.	
✓	To impart knowledge on fundamental concepts of congestion management.	
✓	To analyse the concepts of T and financial transmission rights.	
✓	To illustrate about various power sectors in India.	
✓	To analyse the recent trends and market development in Indian power sector.	
UNIT-I	**INTRODUCTION TO RESTRUCTURING OF POWER INDUSTRY**	9
Introduction: Deregulation of power industry, Restructuring process, Issues involved in deregulation, Deregulation of various power systems – Fundamentals of Economics: Consumer behavior, Supplier behavior, Market equilibrium, Short and long run costs, Various costs of production – Market models: Market models based on Contractual arrangements, Comparison of various market models, Electricity vis – a – vis other commodities, Market architecture, Case study.		
UNIT-II	**TRANSMISSION CONGESTION MANAGEMENT**	9
Introduction: Definition of Congestion, reasons for transfer capability limitation, Importance of congestion management, Features of congestion management – Classification of congestion management methods – Calculation of ATC - Non – market methods – Market methods – Nodal pricing – Inter zonal and Intra zonal congestion management – Price area congestion management – Capacity alleviation method.		
UNIT-III	**LOCATIONAL MARGINAL PRICES AND FINANCIAL TRANSMISSION RIGHTS**	9
Mathematical preliminaries: - Locational marginal pricing– Lossless DCOPF model for LMP calculation – Loss compensated DCOPF model for LMP calculation – ACOPF model for LMP calculation – Financial Transmission rights – Risk hedging functionality - Simultaneous feasibility test and revenue adequency – FTR issuance process: FTR auction, FTR allocation – Treatment of revenue shortfall – Secondary trading of FTRs – Flow gate rights – FTR and market power - FTR and merchant transmission investment.		
UNIT-IV	**ANCILLARY SERVICE MANAGEMENT AND PRICING OF TRANSMISSION NETWORK**	9
Introduction of ancillary services – Types of Ancillary services – Classification of Ancillary services – Load generation balancing related services – Voltage control and reactive power support devices – Black start capability service - How to obtain ancillary service –Co-optimization of energy and reserve services - International comparison - Transmission pricing – Principles – Classification – Rolled in transmission pricing methods – Marginal transmission pricing paradigm – Composite pricing paradigm – Merits and demerits of different paradigm.		
UNIT-V	**REFORMS AND POWER MARKET DEVELOPMENT IN INDIAN POWER SECTOR**	9
Introduction – Framework of Indian power sector – Reform initiatives - Availability based tariff – Electricity act 2003 – Open access issues – Power exchange – Reforms in the near future -Institutional structure in Indian Power sector, generation, transmission and distribution utilities.SO& LDCs.PFC, REC, ERCs, traders, Power Exchanges and their roles		
	Total Contact Hours : 45	
Course Outcomes:		
On completion of the course, the students will be able to		
✓	know restructuring of power industry and market models.	
✓	Understand fundamental concepts of congestion management.	
✓	evaluate locational marginal pricing.	
✓	realize various power sectors in India	
✓	learn the recent trends and market development in Indian power sector.	
Text Book(s):		
1	Sally Hunt, "Making competition work in electricity", John Willey and Sons Inc. 2002	
2	Steven Stoft, "Power system economics: designing markets for electricity", John Wiley & Sons, 2002.	
3	Daniel Kirschen and Goran Strbac, "Fundamentals of Power System economics", John Wiley & Sons Ltd, 2004	
4	Loi Lei Lai , "Power system restructuring and deregulation",Wiley India.	
Reference Books(s) / Web links:		
1	Mohammad Shahidehpour, Muwaffaq Alomoush, Marcel Dekker, "Restructured electrical power systems: operation, trading and volatility" Pub., 2001	
2	Kankar Bhattacharya, Jaap E. Daadler, Math H.J. Boolen, "Operation of restructured power systems", Kluwer Academic Pub., 2001.	
3	https://nptel.ac.in/courses/108/101/108101005/	
4	http://www.inderscience.com/info/ingeneral/cfp.php?id=948	
5	file:///C:/Users/Guest/Downloads/9781852336707-c1.pdf	
Suggested Activities		

1	Splitting the student into different groups and making them involve in the market environment as consumers and bidders, thereby making them understand different types of market models.
2	Preparing Quiz on Power market development in India
Suggested Evaluation Methods CAT Exam , Assignments and Viva-Voce	

COs/POs&PSOs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO 1	3	3	3	3		3	3	1	1	3	2	3	2	3	-
CO 2	3	3	2	2	2	2	3	1	1	3	3	3	3	3	3
CO 3	3	3	3	3	2	2	3	1	1	3	3	3	2	3	3
CO 4	3	3	1	3	1	3	3	1	1	3	3	3	2	3	3
CO 5	3	3		3		3	3			3		3	1	3	-
Average	3.00	3.00	2.25	2.80	1.67	2.60	3.00	1.00	1.00	3.00	2.75	3.00	2.00	3.00	3.00

Subject Code	**Subject Name (Theory course)**	**Category**	**L**	**T**	**P**	**C**
EE23C15	**Power Quality**	**PE**	**3**	**0**	**0**	**3**

Course Objectives:

- To learn the basic definitions in Power Quality
- To study the power quality issues in Single Phase and Three Phase Systems.
- To familiarize voltages sags, interruptions and overvoltage problems
- To understand the principles of Power System Harmonics.
- To impart knowledge on various methods of power quality monitoring

UNIT-I **INTRODUCTION** **9**

Introduction – Characterization of Electric Power Quality: Transients, short duration and long duration voltage variations, Voltage imbalance, waveform distortion, Voltage fluctuations, Power frequency variation, Power acceptability curves – power quality problems: poor load power factor, Non-linear and unbalanced loads, DC offset in loads, Notching in load voltage, Disturbance in supply voltage – Power quality standards.

UNIT-II **ANALYSIS OF SINGLE PHASE AND THREE PHASE SYSTEM** **9**

Single phase linear and non-linear loads – single phase sinusoidal, non-sinusoidal source – supplying linear and nonlinear loads – three phase balanced system – three phase unbalanced system – three phase unbalanced and distorted source supplying non-linear loads – concept of power factor – three phase- three wire – three phase - four wire system.

UNIT-III **VOLTAGE SAGS, INTERRUPTIONS AND OVERVOLTAGES** **9**

Sources of sags and interruptions - estimating voltage sag performance. Voltage sag due to induction motor starting. Estimation of the sag severity - mitigation of voltage sags, active series compensators. Static transfer switches and fast transfer switches. Sources of over voltages - Capacitor switching – lightning - ferro resonance. Mitigation of voltage swells - surge arresters - low pass filters - power conditioners. Lightning protection – shielding – line arresters - protection of transformers and cables.

UNIT-IV **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 - Inter harmonics – Resonance Harmonic distortion evaluation, IEEE and IEC standards

UNIT-V **POWER QUALITY MONITORING** **9**

Monitoring considerations - monitoring and diagnostic techniques for various power quality problems - modelling of power quality (harmonics and voltage sag) problems by mathematical simulation tools - power line disturbance analyser – quality measurement equipment - harmonic / spectrum analyser - flicker meters - disturbance analyser.

Contact Hours : 45

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

- Understand and comprehend the various power quality problems
- Describe the concepts related with single phase / three phase, linear / nonlinear loads and single phase / three phase
- Realize various sources and mitigation methods for voltage sag, interruptions and overvoltage.

●	Evaluate various harmonic effects
●	Understand and analyse power quality monitoring.
Suggested Activities	
• Group Seminar/Mini Project	
Suggested Evaluation Methods	
• Quiz • Assignment	
Text Book (s):	
1	R.C.Duggan "Electric Power Systems Quality", Tata MC Graw Hill Publishers, Third Edition, 2012
2	Arindam Ghosh and Gerad Ledwich "Power Quality Enhancement Using Custom Power Devices", Kluwer Academic Publishers, First Edition,2002
3	G.T.Heydt, "Electric Power Quality", Stars in a Circle Publications, Second Edition, 2011.
Reference Books(s) :	
1	Arrillga "Power System Harmonics", John Wiely and Sons, 2003 2nd Edition.
2	George J. Wakileh, "Power System Harmonics – Fundamentals, Analysis and Filter Design", Springer – Verlag Berlin Heidelberg, New York, 2019.
3	Derek A.Paice "Power Electronic Converter Harmonics" IEEE Press, 1995, Wiley – IEE Press 1999, 18th Edition.
Web links :	
1	Introduction to Power Quality (amu.ac.in)
2	Mitigation-of-Harmonics.pdf (cde.com)
3	Power System Harmonics - Analysis, Effects and Mitigation Solutions for Power Quality Improvement | IntechOpen

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	3	-	-	3	3	-	3	-	3	3	3	3
CO 2	3	3	3	3	-	-	3	3	-	3	-	3	3	3	3
CO 3	3	3	3	3	-	-	3	3	-	3	-	3	3	3	3
CO 4	3	3	3	3	-	-	3	3	-	3	-	3	3	3	3
CO 5	3	3	3	3	-	-	3	3	-	3	-	3	3	3	3
Average	3	3	3	3	-	-	3	3	-	3	-	3	3	3	3

Subject Code	**Subject Name (Theory course)**	**Category**	**L**	**T**	**P**	**C**
EE23C16	**POWER SYSTEM DYNAMICS**	**PE**	**3**	**0**	**0**	**3**
Objectives:						
●	To impart knowledge on the basics of dynamics and stability problems					
●	To provide knowledge on modelling of synchronous machines					
●	To learn the excitation system and speed-governing controllers					
●	To study small signal stability of a single-machine infinite bus system with excitation system and power system stabilizer					
●	To learn transient and dynamic stability of multi machine power systems					
UNIT-I	**INTRODUCTION**					9
Basics of system dynamics – numerical techniques – introduction to software packages to study the responses. Concept and importance of power system stability in the operation and design – distinction between transient and dynamic stability.						
UNIT-II	**SYNCHRONOUS MACHINE MODELLING**					9

Synchronous machine - Park's transformation - per unit quantities - equivalent circuit - current space model. Sub-transient and transient inductances - time constants. Simplified models (one axis and constant flux linkage) - steady state equations and phasor diagrams.		
UNIT-III	**MACHINE CONTROLLERS**	9
Exciter and voltage regulators - function and types of excitation systems - typical excitation system configuration - block diagram and state space representation of IEEE type 1 excitation system. Function of speed governing systems - block diagram and state space representation of IEEE mechanical hydraulic governor and electrical hydraulic governors for hydro turbine.		
UNIT-IV	**TRANSIENT STABILITY**	9
State equation for multi machine system with one axis model – modelling of multi machine power system with one axis machine model including excitation system and speed governing system - power system stabilizer.		
UNIT-V	**DYNAMIC STABILITY**	9
System response to small disturbances - linear model of the unregulated synchronous machine - regulated synchronous machine – linearization of the load equation for the one machine problem – simplified linear model - effect of excitation on dynamic stability - approximate system representation - supplementary stabilizing signals – dynamic performance measure.		
	Total Contact Hours : 45	

Course Outcomes: At the end of the course the student will be able to	
●	Understand the basics of dynamics and stability problems
●	analyze modelling of synchronous machines
●	analyze the excitation system and speed-governing controllers.
●	determine small signal stability of a single-machine infinite bus system with excitation system and power system stabilizer.
●	estimate transient and dynamic stability of a multi machine power system.
Text Book (s):	
1	P. Kundur, "Power System Stability and Control", McGraw Hill Inc., USA, 1994.
2	R.Ramanujam, "Power System Dynamics – Analysis and Simulation", PHI, 2009.
3	M.A.Pai and W.Sauer, "Power System Dynamics and Stability", Pearson Education Asia, India,2002.
Reference Books(s) / Web links:	
1	James A.Momoh, Mohamed. E. EI-Hawary. "Electric Systems, Dynamics and Stability with Artificial Intelligence applications", Marcel Dekker, USA First Edition, 2000.
2	C.A.Gross, "Power System Analysis," Wiley India, 2011.
3	B.M.Weedy, B.J.Lory, N.Jenkins, J.B.Ekanayake and G.Strbac,"Electric Power Systems",Wiley India, 2013.

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	2	2		1					2	3	3	2
CO 2	3	3	3	2	2		1					2	3	3	2
CO 3	3	3	3	2	2		1					2	3	3	2
CO 4	3	3	3	2	2		1					2	3	3	2
CO 5	3	3	3	2	2		1					2	3	3	2
Average	**3**	**3**	**3**	**2**	**2**		**1**					**2**	**3**	**3**	**2**

VERTICAL IV - ADVANCED POWER ELECTRONIC SYSTEMS

Subject Code	Subject Name (Theory Course)	Category	L	T	P	C
EE23D11	ANALYSIS OF ELECTRICAL MACHINES	PE	3	0	0	3

Objectives:

- To model and simulate different types of DC machines
- To develop reference frame equations for various elements like R, L and C
- To model an induction (three phase and 'n' phase) and synchronous machine
- To derive reference frame equations for induction and synchronous machines
- To study the need and working of multiphase induction and synchronous machines

UNIT-I	**MODELING AND SIMULATION OF BRUSHED-DC ELECTRIC MACHINERY**	**9**

Fundamentals of Operation – Introduction – Governing equations and modeling of Brushed DC-Motor – Shunt, Series and Compound – State model derivation – Construction of Model for a DC Machine using state equations- Simulation under no-load and loaded conditions-Simulation of soft starting for DC motor

UNIT-II	**REFERENCE FRAME THEORY**	**9**

Historical background –Three phase to two phase transformation – transformation of variables from stationary to arbitrary reference frame, Dynamic modeling-stator reference model, rotor reference model, Flux linkage equations, PU model

UNIT-III	**INDUCTION MACHINES**	**9**

Three phase induction machine – dq equivalent circuit– Ghani model - free acceleration characteristics – voltage and torque equations in machine variables and arbitrary reference frame variables – Simulation under no-load and load conditions- Machine variable form, arbitrary reference variable form

UNIT-IV	**SYNCHRONOUS MACHINES**	**9**

Three phase synchronous machine –Blondel's model, voltage and torque equations in machine variables and rotor reference frame variables (Park's equations) – Simulation under no-load and load conditions- Machine variable form, arbitrary reference variable form

UNIT-V	**MULTIPHASE (MORE THAN THREE-PHASE) MACHINE CONCEPTS**	**9**

Preliminary Remarks - Necessity of Multiphase Machines - Evolution of Multiphase Machines- Advantages of Multiphase Machines - Working Principle - Multiphase Induction Machine, Multiphase Synchronous Machine - Modeling of 'n' phase machine -Applications of Multiphase Machines

Total Contact Hours	**:**	**45**

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

- Formulate the model for brushed DC-Motors (Shunt, Series, Compound and separately excited motor) and understand about simulation of DC motors using state model
- Apply reference frame theory for resistive and reactive elements (three phase)
- Compute the torque of three phase induction motor and synchronous motor in machine variable arbitrary reference frame variable
- Find the need and advantages of multiphase machines
- Demonstrate the working of multiphase induction and synchronous machine.

Text Book (s):

1. Paul C. Krause, Oleg Wasynczuk, Scott D. Sudhoff, Steven D. Pekarek, "Analysis of Electric Machinery and Drive Systems", 3rd Edition, Wiley-IEEE Press, 2013.
2. Anderson and Foud, "Power system stability and control"IEEE Press, 2003
3. R. Ramanujam, Modeling and Analysis of Electrical Machines, I. k. International Publishing House Pvt.Ltd,2018

Reference Books(s) :

1. Stephen D. Umans, "Fitzgerald & Kingsley's Electric Machinery", Tata McGraw Hill, 7th Edition, 2020.
2. Bogdan M. Wilamowski, J. David Irwin, The Industrial Electronics Handbook, Second Edition, Power Electronics and Motor Drives, CRC Press, 2011
3. R. Krishnan, Electric Motor & Drives: Modeling, Analysis and Control, Pearson Education, 1st Imprint, 2015.
4. Chee Mun Ong ,Dynamic Simulation of Electric Machinery using MATLAB, , Prentice Hall, 1997

5	*Atif Iqbal,Shaikh Moinoddin, Bhimireddy Prathap Reddy,* Electrical Machine Fundamentals with Numerical Simulation using MATLAB/SIMULINK, *Wiley,2021*
6	P.S.*Bimbhra "Generalized theory of Electrical Machines, khanna Publications,2011*
Web links :	
1.	https://archive.nptel.ac.in/courses/108/106/108106023/
2.	https://www.intechopen.com/chapters/71794

Suggested activities:

- To learn Magnet software
- To learn Matlab simulink software

Suggested Evaluation methods:

- To evaluate students based on Magnet assignments
- To evaluate students based on Matlab assignments

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	3	3	-	2	1	-	3	-	2	3	3	3
CO 2	3	3	3	3	3	-	2	1	-	3	-	2	3	3	3
CO 3	3	3	3	3	3	-	2	1	-	3	-	2	3	3	3
CO 4	3	-	-	-	-	-	2	1	-	3	-	2	3	3	3
CO 5	3	-	-	-	-	-	2	1	-	3	-	2	3	3	3
Average	3	3	3	3	3	-	2	1	-	3	-	2	3	3	3

Subject Code	Subject Name (Theory Course)	Category	L	T	P	C
EE23D12	**POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS**	**PE**	**3**	**0**	**0**	**3**

Objectives:

- To learn the variable types of renewable sources of energy.
- To understand the electrical machines to be used for wind energy conversion systems.
- To learn the principles of power converters used in solar PV system
- To study the principle of power converters used for wind power system
- To simulate the AC-DC, AC-AC Converters and PWM Inverters

UNIT-I	**INTRODUCTION TO RENEWABLE ENERGY SYSTEMS**	**9**

Classification of Energy Sources – Importance of Non-conventional energy sources – Advantages and disadvantages of conventional energy sources - Environmental aspects of energy - Impacts of renewable energy generation on the environment - Qualitative study of renewable energy resources: Ocean energy, Biomass energy, Hydrogen energy,Tidal Energy - Solar Photovoltaic (PV), Fuel cells: Operating principles and characteristics, Wind Energy: Nature of wind systems;

UNIT-II	**ELECTRICAL MACHINES FOR WIND ENERGY CONVERSION SYSTEMS (WECS)**	9

Construction, Principle of operation and analysis: Squirrel Cage Induction Generator (SCIG), Doubly Fed Induction Generator (DFIG) with single and two speed systems - Permanent Magnet Synchronous Generator (PMSG).

UNIT-III	**POWER CONVERTERS AND ANALYSIS OF SOLAR PV SYSTEMS**	9

Power Converters: Line commutated converters (inversion-mode) - Boost and buck-boost converters- selection of inverter, battery sizing, array sizing. Simulation of line commutated converters, buck/boost converters.

Analysis: Block diagram of the solar PV systems - Types of Solar PV systems: Stand-alone PV systems. Factors affecting solar cell efficiency-Effect of partial shading using dc-dc converter

UNIT-IV	**POWER CONVERTERS FOR WIND ENERGY SYSTEMS**	9

Power Converters: Three-phase AC voltage controllers- AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters, Grid-Interactive Inverters - Matrix converter.

Simulation study of AC-AC converters, PWM rectifier and inverters (Single and three phase)

UNIT-V	HYBRID RENEWABLE ENERGY SYSTEMS			9
Need for Hybrid Systems- Range and type of Hybrid systems- Case studies of Diesel-PV, Wind-PV,-Biomass-Diesel systems - Maximum Power Point Tracking (MPPT).				
		Total Contact Hours	**:**	**45**

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

- Examine the available renewable energy sources.
- Demonstrate the working principles of electrical machines and power converters used for wind energy conversion system
- Demonstrate the principles of power converters used for solar PV systems
- Examine the available hybrid renewable energy systems.
- Simulate AC-DC converters, buck/boost converters, AC-AC converters and PWM inverters.

Text Book (s):

1. S.N.Bhadra, D. Kastha, & S. Banerjee "Wind Electrical Systems", Oxford University Press, 2009
2. Rashid .M. H "Power electronics Hand book", Academic press,2nd Edition, 2006 4th Edition, 2017

Reference Books(s) :

1. Rai. G.D, "Non-conventional energy sources", Khanna publishers, 2010.
2. Rai. G.D," Solar energy utilization", Khanna publishers, 5th Edition, 2008.
3. Gray, L. Johnson, "Wind energy system", prentice hall of india, 1995.
4. B.H.Khan "Non-conventional Energy sources ",Tata McGraw-hill Publishing Company, New Delhi, 2017.

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	2	2	-	2	2	1	1	-	1	1	2	2	-
CO 2	3	3	2	2	-	2	2	1	1	-	1	1	2	2	-
CO 3	3	3	3	2	1	2	2	1	1	-	1	1	3	3	3
CO 4	3	3	3	1	3	1	1	1	1	-	1	1	3	3	3
CO 5	3	3	1	1	-	1	1	1	1	-	1	1	1	1	-
Average	**3**	**3**	**2.2**	**2**	**1**	**1.6**	**1.6**	**1**	**1**	**-**	**1**	**1**	**2.2**	**2.2**	**1.2**

Course Code	Course Title(Theory Course)	Category	L	T	P	C
EE23D13	**MULTILEVEL POWER CONVERTERS**		**3**	**0**	**0**	**3**

Course Objectives:

- To learn multilevel topology (Symmetry & Asymmetry) with common DC bus link
- To study the working of cascaded H Bridge, Diode Clamped and Flying Capacitor MLI
- To study the working of MLI with reduced switch count.
- To simulate three level diode clamped MLI and three level flying capacitor based MLI
- To simulate the grid tied inverter

UNIT-I	MULTILEVEL TOPOLOGIES	9
Introduction – Generalized Topology with a Common DC bus – Converters derived from the generalized topology – symmetric topology without a common DC link – Asymmetric topology.		
UNIT-II	**CASCADED H-BRIDGE MULTILEVEL INVERTERS**	**9**
Introduction -H-Bridge Inverter ,Bipolar Pulse Width Modulation , Unipolar Pulse Width Modulation Multilevel Inverter Topologies, , CHB Inverter with Equal DC Voltage , H-Bridges with Unequal DC Voltages – PWM, Carrier-Based PWM Schemes , Phase-Shifted Multicarrier Modulation , Level-Shifted Multicarrier Modulation , Comparison Between Phase- and Level-Shifted PWM Schemes- Staircase Modulation		
UNIT-III	**DIODE CLAMPED MULTILEVEL CONVERTER**	**9**
Introduction – Converter structure and Functional Description – Modulation of Multilevel converters – Voltage balance Control – Effectiveness Boundary of voltage balancing in DCMC converters – Performance results. Simulation of three level diode clamped MLI with R and RL load.		

UNIT-IV	FLYING CAPACITOR MULTILEVEL CONVERTER	9
Introduction – Flying Capacitor topology – Modulation scheme for the FCMC – Dynamic voltage balance of FCMC. Simulation of a three level capacitor clamped MLI with R and RL load.		
UNIT-V	**CONTROL OF GRID-CONNECTED MODULAR MULTILEVEL CONVERTERS**	**9**
Control of grid-connected modular multilevel converter, Control of the MMC for High-Voltage DC (HVDC) transmission		
	Contact Hours : 45	

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

- Examine the different topologies of multi-level inverters (MLIs) with and without DC link capacitor. PWM Carrier-Based PWM Schemes and Phase Level Shifted Multicarrier Modulation
- Examine the performance of MLIs with Bipolar Pulse Width Modulation (PWM) Unipolar
- Demonstrate the working principles of Cascaded H-Bridge MLI, diode clamped MLI, flying capacitor MLI and MLI with reduced switch count
- Analyse the voltage balancing performance in Diode clamped MLI
- Simulate three level, capacitor clamed and diode clamped MLI

Suggested Activities

- To simulate a multi-level inverter with different PWM schemes using MATLAB/SIMULINK.

Suggested Evaluation Methods

- To implement a hardware project on one of the multilevel converters

Text Book (s):

1	Rashid M.H,"Power Electronics Circuits, Devices and Applications", Prentice Hall India, Third Edition, New Delhi, 2014 Pearson 3rd edition.
2	Sergio Alberto Gonzalez, Santiago Andres Verne, Maria Ines Valla,"Multilevel Converters for Industrial Applications", CRC Press, 22-Jul-2013, 2017
3	High Power Converters and AC drives by BinWu, Mehdi Narimani, IEEE press 2017

Reference Books(s) :

1	Pulse Width Modulation for Power Converters: Principles and Practice, D.Grahame Holmes, Thomas A. Lipo John Wiley & Sons, Oct-2003
2	Advanced DC/AC Inverters: Applications in Renewable Energy, Fang Lin Luo, Hong Ye, CRC Press, 22-Jan-2013, 2017
3	Single-DC-Source Multilevel Inverters, Hani Vahedi, Mohamed Trabelsi, Springer, 2019
4	Multilevel Inverters Introduction and Emergent Topologies, Ersan Kabalcı, Academic Press Inc,2021
5	Advanced Multilevel Converters and Applications in Grid Integration, Iftekhar Maswood, Dehghani Tafti, Wiley, 2018.
6	Rashid M.H," Power Electronics Hand book ", Elsivier,2017

Web links :

1	https://iten.ieee-ies.org/journal-featured-article/2022/modular-multilevel-converters-recent-achievements-and-challenges/
2	https://www.mdpi.com/1996-1073/12/4/615

COs/POs &PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3		2	2	2								2	2	3
CO 2	3	3	2	2	2			2					2	2	3
CO 3	3	3	2	2	2							2	2	2	3
CO 4	3	3	2	2	2							2	2	2	3
CO 5	3	3	2	2	2							2	2	2	3
Average	**3**	**3**	**2**	**2**	**2**			**2**				**2**	**2**	**2**	**3**

Subject Code	Subject Name(Theory Course)	Category	L	T	P	C

EE23D14	MODERN RECTIFIERS AND RESONANT CONVERTERS	PE	3	0	0	3

Objectives:

- To provide knowledge on harmonics standards.
- To acquire knowledge on PWM rectifiers for UPS applications.
- To inculcate knowledge on resonant converters for SMPS applications.
- To get familiarized with the dynamic analysis of DC to DC converters.
- To learn different types of controllers for resonant converters.

UNIT-I	POWER SYSTEM HARMONICS & LINE COMMUTATED RECTIFIERS	9

Average power-RMS value of a waveform-Power factor-AC line current harmonic standards IEC 1000-IEEE 519- The Single phase full wave rectifier-Continuous Conduction Mode- Discontinuous Conduction Mode- Behaviour when C is large-Minimizing THD when C is small- Three phase rectifiers- Continuous Conduction Mode-Discontinuous Conduction Mode- Harmonic trap filters.

UNIT-II	PULSE WIDTH MODULATED RECTIFIERS	9

Properties of Ideal rectifiers-Realization of non-ideal rectifier-Control of current waveform- Average current control-Current programmed Control- Hysteresis control- Nonlinear carrier control-Single phase converter system incorporating ideal rectifiers- Modeling losses and efficiency in CCM high quality rectifiers-Boost rectifier Example - expression for controller duty cycle-expression for DC load current-solution for converter Efficiency η.

UNIT-III	RESONANT CONVERTERS	9

Review on Parallel and Series Resonant Switches-Soft Switching- Zero Current Switching – Zero Voltage Switching - Classification of Quasi resonant switches-Zero Current Switching of Quasi Resonant Buck converter, Zero Current Switching of Quasi Resonant Boost converter, Zero Voltage Switching of Quasi Resonant Buck converter, Zero Voltage Switching of Quasi Resonant Boost converter: Steady State analysis

UNIT-IV	DYNAMIC ANALYSIS OF SWITCHING CONVERTERS	9

Review of linear system analysis-State Space Averaging-Basic State Space Average Model- State Space Averaged model for an Buck Converter, Boost Converter, Buck Boost Converter, and Cuk Converter.

UNIT-V	CONTROL OF RESONANT CONVERTERS	9

Pulse Width Modulation-Voltage Mode PWM Scheme-Current Mode PWM Scheme-Design of Controllers: PI Controller, Variable Structure Controller, Optimal Controller for the source current shaping of PWM rectifiers.

Total Contact Hours	:	45

Course Outcomes:

At the end of the course the student will be able to

- To comprehend the standards for supply current harmonics and its significance.
- To apply the concept of various types of rectifiers.
- To realize and simulate the operation of resonant converter and its importance.
- To elucidate the importance of linear system, state space model, PI controller.
- To design a controllers for resonant converters.

Suggested Activities

- Mini projects can be done in Resonant Converters
- Simulation of Converters can be done by MATLAB/SIMULINK software tool

Suggested Evaluation Methods

- Assignment
- Assessment

Text Book(s):

1	Robert W. Erickson and Dragon Maksimovic, “Fundamentals of Power Electronics”, Second Edition, Springer science and Business media, 2001.
2	William Shepherd and Li zhang, “Power Converters Circuits”, MarceldEkkerin,C, 2005.
3	Simon Ang and Alejandro Oliva, “Power Switching Converters”, Taylor & Francis Group, 2010.

Reference Books(s) / Web links:

1	Andrzej M. Trzynadlowski, “Introduction to Modern Power Electronics”, John Wiley
2	Marian.K.Kazimierczuk and Dariusz Czarkowski, “Resonant Power Converters”, John Wiley & Sons limited, 2011.
3	Keng C .Wu, “Switch Mode Power Converters – Design and Analysis” Elseveir academic press, 2006.
4	Abraham I.Pressman, Keith Billings and Taylor Morey, “Switching Power Supply Design” McGraw-Hill ,2009

5	V.Ramanarayanan, "Course Material on Switched Mode Power Conversion" IISC, Banglore, 2007.
6	Christophe P. Basso, "Switch-Mode Power Supplies", McGraw-Hill ,2014
Web links :	
7	https://ieeexplore.ieee.org/document/5243926

COs/POs&PSOs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO 1	3	3	3	3	3				1	1	1	2	3	3	3
CO 2	3	3	3	3	3				1	1	1	2	3	3	3
CO 3	3	3	3	3	3				1	1	1	2	3	3	3
CO 4	3	3	3	3	3				1	1	1	2	3	3	3
CO 5	3	3	3	3	3				1	1	1	2	3	3	3
Average	**3**	**3**	**3**	**3**	**3**				**1**	**1**	**1**	**2**	**3**	**3**	**3**

Course Code	**Course Title(Theory Course)**	**Category**	**L**	**T**	**P**	**C**
EE23D15	**SMPS and UPS**	**PE**	**3**	**0**	**0**	**3**

Course Objectives:

- To develop the state space model of DC-DC converter.
- To develop the state space model of Switched Mode Power Converters
- To learn about various modes of operation of Resonant converter
- To impart the knowledge on PWM techniques and multilevel inverter
- To learn about operation of UPS and able to design the filter for SMPS

UNIT-I	**DC-DC CONVERTERS**	**9**

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

UNIT-II	**SWITCHED MODE POWER CONVERTERS**	**9**

Analysis and state space modelling 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, need for filter, Design of input filter and EMI filter for SMPS – Design of inductor and transformer for PE applications.

Contact Hours	**:**	**45**

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

- analyze the state space model for DC – DC converters
- Model and analyse the switched mode power converters
- understand the importance of Resonant Converters.
- analyze the PWM techniques for DC-AC converters
- Comprehend the components of filters and UPS.

Suggested Activities

• Technical quiz • Mini project	
Suggested Evaluation Methods • Assignment • Continuous Assessment Test	
Text Book (s):	
1	Simon Ang, Alejandro Oliva," Power-Switching Converters", Third Edition, CRC Press, 2010.
2	KjeldThorborg, "Power Electronics – In theory and Practice", Overseas Press, First Indian Edition 2005.
3	M.H. Rashid – Power Electronics handbook, Elsevier Publication,2011
Reference Books(s) :	
1	Ned Mohan, Tore.M.Undeland, William.P.Robbins, Power Electronics converters, Applications and design- Third Edition- John Wiley and Sons- 2006
2	Philip T Krein, "Elements of Power Electronics", Oxford University Press
3	Ned Mohan, Tore.M.Undeland, William.P.Robbins, Power Electronics converters, Applications and design- Third Edition- John Wiley and Sons- 2006
4	M.H. Rashid – Power Electronics circuits, devices and applications- third edition Prentice Hall of India New Delhi, 2007.
5	Erickson, Robert W, "Fundamentals of Power Electronics", Springer, second edition, 2010.
Web links :	
1	https://www.ti.com/lit/an/snva538/snva538.pdf?ts=1698820877079&ref_url=https%253A%252F%252Fwww.google.com%252F
2	https://ieeexplore.ieee.org/abstract/document/7409511

COs/POs&PSOs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO 1	3	3	3	3			2					3	3	1	
CO 2	3	3	3	3			2					3	3	1	
CO 3	3	3	3	3			2					3	3	1	
CO 4	3	3	3	3			2					3	3	1	
CO 5	3	3	3	3			2					3	3	1	
Average	**3**	**3**	**3**	**3**			2					**3**	**3**	**1**	

Subject Code	**Subject Name(Lab Oriented Theory Course)**	**Category**	**L**	**T**	**P**	**C**
EE23D31	**CONTROL OF POWER ELECTRONIC CIRCUITS**	**PC**	**2**	**0**	**2**	**3**

Objectives:	
●	To teach the basics of state space modelling and derivation of Transfer Function of Power Converters
●	To impart knowledge on VMC and CMC methods of control
●	To provide knowledge on the design of PI and PID Controller design Using Z-N and GA based optimization techniques
●	To teach the design methods for Hysteresis and State Feedback Controller
●	To provide knowledge on the closed loop control of power converters for different applications

UNIT-I	**STATE SPACE MODELLING OF POWER CONVERTERS**	6
Selection of State variables for Power Converters – Applications of KVL and KCL in State Space Modelling - Mathematical modelling /State Space Modelling of Buck - Boost, Cuk, and SEPIC DC-DC Converters operating in Continuous Conduction Mode (CCM) – State Space Modelling of Voltage Source Inverter - Derivation of Transfer function from the State Space Model.		
UNIT-II	**INTRODUCTION TO CLOSED LOOP CONTROL OF POWER CONVERTERS**	6
Need for Closed Loop Control – Voltage Mode Control (VMC) – Current Mode Control (CMC) – Advantages of CMC over VMC –Cascade Control Strategy – Condition for implementing Cascade Control Strategy - Introduction to fixed and variable frequency PWM methods.		

UNIT-III	DESIGN OF PROPORTIONAL INTEGRAL DERIVATIVE CONTROLLER	6
Effect of Proportional (P) – Integral (I) – Derivative (D) Controllers- Proportional Integral (PI) Controller - Proportional Integral Derivative (PID) Controller - Design of PI and PID controller parameters for DC-DC Cuk and SEPIC Converter- Zeigler- Nichol's Tuning Method - Genetic Algorithm Based optimization		
UNIT-IV	**DESIGN OF HYSTERESIS AND STATE FEEDBACK CONTROLLER**	6
Design of Hysteresis Controller (HC) – Factors to be considered for the selection of Hysteresis Band – Drawbacks of Variable frequency control – Introduction to Controllable Canonical or Phase variable form - Kalman's Test for Controllability and Observability – State Feedback Controller (SFC) Design for DC-DC Buck Converter - Pole Placement Method – Ackermann's Formula.		
UNIT-V	**APPLICATIONS OF VARIOUS CONTROL SCHEMES**	6
VMC and CMC Control of Buck, Boost DC-DC Converters. Closed loop control of DC-DC Cuk and SEPIC Regulators Using PID controller – Closed loop control of DC- DC SEPIC Converter fed DC Motor Using PI Controller – SFC Control of DC-DC Buck Converter for Battery Charging Applications – Hysteresis Control of Boost Converter – Closed loop control of Single phase VSI using Hysteresis Controller - Application of control schemes to Battery operated vehicle, PV system.		
	Total Contact Hours : 30	

EXPERIMENTS

1	Performance Comparison of VMC and CMC Control of DC-DC SEPIC Regulator Using Matlab (In terms of Time domain Specifications)
2	PID Controller based DC-DC Cuk Regulator Using Matlab
3	Design of State Feedback Controller for DC-DC Buck Converter for Battery Charging Application Using Matlab
4	Closed loop control of DC Motor Using. PI controller Based DC-DC SEPIC Converter Via Matlab
5	Hysteresis Control of Boost Converter Using Matlab
6	Closed loop control of Hysteresis Control Based Single phase VSI using Matlab

		Lab Contact Hours	**:**	**15**		**Lab Contact Hours**	**:**	**15**	
		Total Contact Hours	**:**	**45**		**Total Contact Hours**	**:**	**45**	

Course Outcomes:

At the end of the course the student will be able to

●	understand the basics of state space modelling and to derive the Transfer Function of Power Converters
●	realize the VMC and CMC methods of of Power Converters
●	design PI and PID Controller parameters Using Z-N and GA based optimization technique for Power Converters
●	design for Hysteresis and State Feedback Controller for Power Converters
●	realize the closed loop control of power converters using PI, PID Controller, Hysteresis and State feedback controller for different applications using Matlab.

Text Book(s):

1	Robert W. Erickson and Dragon Maksimovic, "Fundamentals of Power Electronics", Second Edition, Springer science and Business media, 2001.
2	William Shepherd and Li zhang, "Power Converters Circuits", MarceldEkkerin,C, 2005.
3	Simon Ang and Alejandro Oliva, "Power Switching Converters", Taylor & Francis Group, 2010.

Reference Books(s) / Web links:

1	Keng C .Wu, "Switch Mode Power Converters – Design and Analysis" Elseveir academic press, 2006.
2	Abraham I.Pressman, Keith Billings and Taylor Morey, "Switching Power Supply Design" McGraw-Hill ,2009
3	V.Ramanarayanan, "Course Material on Switched Mode Power Conversion" IISC, Banglore, 2007.
4	Christophe P. Basso, "Switch-Mode Power Supplies", McGraw-Hill ,2014
5	Andrzej M. Trzynadlowski, "Introduction to Modern Power Electronics", John Wiley

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	3	3							1	3	3	3
CO 2	3	3	3	3	3							1	3	3	3
CO 3	3	3	3	3	3							1	3	3	3

CO 4	3	3	3	3	3							1	3	3	3
CO 5	3	3	3	3	3							1	3	3	3
Average	**3**	**3**	**3**	**3**	**3**							**1**	**3**	**3**	**3**

VERTICAL V- ADVANCED CONTROL SYSTEM ENGINEERING

Course Code	**Course Title(Theory Course)**	**Category**	**L**	**T**	**P**	**C**
EE23E11	**ADVANCED CONTROL SYSTEMS**	**PE**	**3**	**0**	**0**	**3**

Course Objectives:

- To provide adequate knowledge on modelling and representing systems in state variable form.
- To teach the basic knowledge in obtaining the solution of state equations.
- To inculcate the role of controllability and observability
- To familiarise the modal concepts and design of state and output feedback controllers and estimators.
- To impart knowledge on the phase plane analysis and overview of control systems for mobility applications.

UNIT-I	**STATE VARIABLE REPRESENTATION**	9

Introduction-Concept of State variable –state assignment-State equation for Dynamic Systems – electrical , mechanical and electromechanical system-state diagram- Time invariance and linearity- Non uniqueness of state model.

UNIT-II	**SOLUTION OF STATE EQUATIONS**	9

Existence and uniqueness of solutions to Continuous-time state equations-Solution of Nonlinear and Linear Time Varying State equations-Evaluation of matrix exponential-System modes- Role of Eigen values and Eigenvectors.

UNIT-III	**CONTROLLABILITY AND OBSERVABILITY**	9

Controllability and Observability- Stabilizability and Detectability-Gilbert's and Kalman's Test for Continuous time Systems- Time varying and Time invariant case-Output Controllability-Reducibility-System Realizations.

UNIT-IV	**MODAL CONTROL**	9

Introduction-Controllable and Observable Companion Forms-SISO and MIMO Systems-The Effect of State Feedback on Controllability and Observability-Pole Placement by State Feedback for both SISO and MIMO Systems-Full Order and Reduced Order Observers.

UNIT-V	**PHASE PLANE ANALYSIS AND A CASE STUDY ON OVERVIEW OF CONTROL SYSTEMS IN ELECTRIC MOBILITY**	9

Features of linear and non-linear systems -Concept of phase portraits – Singular points – Limit cycles – Construction of phase portraits – Phase plane analysis of linear and non-linear systems – Isocline method.
Case study: key applications of control systems in electric mobility.

Contact Hours	**:**	**45**

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

- determine the state space representation of various control system.
- analyse the nonlinear and linear time varying system using state equations
- estimate the controllability and observability of the system.
- determine the state feedback for both SISO and MIMO systems
- analyse the linear and non-linear systems using phase plane analysis and get a glimpse of control system in electric mobility applications.

Suggested Activities

- Problem solving tutorial sessions

Suggested Evaluation Methods

- Continuous Assessment Tests, Assignment, End Semester Exam

Text Book (s):

1	K. Ogatta, "Modern Control Engineering", PHI, 5th edition 2015.
2	M. Gopal, "Modern Control System Theory", New Age International, 3rd edition , 2014
3	Bernard Friedland, "Advanced Control Systems Design", Pearson Education India; First edition, 2015
4	Richard C Dorf, Robert H bishop ,"Modern Control System" ,Pearson Education India; 12th edition, 2013
5	Uwe Kiencke and Lars Nielsen, "Automotive Control Systems: For Engine, Driveline, and Vehicle" , Springer Berlin, Heidelberg, 2015.

Reference Books(s) :	
1	I.J. Nagrath and M. Gopal, 'Control Systems Engineering', New Age International Publishers, 2003.
2	Gene F. Franklin, J. David Powell and Abbasemami -Naeini, "Feedback Control of Dynamic Systems", Fourth edition, Pearson Education, 2002.
3	Ashish Tewari, 'Modern control Design with Matlab and Simulink', John Wiley, New Delhi, 2002.
4	B.N Sarkar,"Advanced Control Systems", PHI Learning Private Limited; 1st edition, 2013
5	Norman S Nise, "Nise's Control Systems Engineering", Wiley India Ed, 2018.
Web links :	
1	IEEE Guide to Autonomous Vehicle Technology
2	http://www.ieeecss.org/

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	3	3	3	2			2	1	3	3	3	2
CO 2	3	3	3	3	3	3	2					3	3	3	3
CO 3	3	3	3	3	3	3	2					3	3	3	3
CO 4	3	3	3	3	3	3	2					3	3	3	3
CO 5	3	3	3	3	3	3	2	2	3	2		3	3	3	3
Average	**3**	**3**	**3**	**3**	**3**	**3**	2	2	**3**	**2**	**1**	**3**	**3**	**3**	**3**

Subject Code	Course Title(Theory Course)	Category	L	T	P	C
EE23E12	**DIGITAL CONTROL SYSTEMS**	**PE**	**3**	**0**	**0**	**3**

Objectives:

- To study the importance of sampled data control system.
- To impart adequate knowledge about signal processing in digital control.
- To study the importance of modeling of discrete systems and stability analysis of discrete data system.
- To study the importance of state space representation for discrete data system.
- To provide knowledge on the design concept for digital controllers.

UNIT-I	COMPUTER CONTROLLED SYSTEM	9

Configuration of the basic digital control system – general sampled data system variables – signal classifications – Significance of digital control system –Advantages – disadvantages – examples of discrete data and digital control systems.

UNIT-II	SIGNAL PROCESSING IN DIGITAL CONTROL	9

Sampling process – Frequency domain analysis –ideal samples– Shanon's sampling theorem –generation and solution of process –linear difference equations –Data reconstruction process –Frequency domain characteristics.

UNIT-III	DISCRETE SYSTEM MODELLING	9

Determination of the Z transform – Mapping between s and Z domains-Z transform of system equations –Open loop Hybrid sampled Data Control Systems –Open loop discrete Input Data Control System –Closed loop sampled data control system –modified Z transform method – Response between sampling instants –Stability on the Z-plane and Jury's stability test –Steady state error analysis for stable systems

UNIT-IV	STATE VARIABLE ANALYSIS OF DIGITAL CONTROL SYSTEMS	9

State descriptions of digital process –Conversion of state variable models to transfer function – Conversion of transfer functions to canonical state variable models – Companion forms –Jordon Canonical form – State description of sampled continuous time plants –Solution of state difference equations –State transition matrix –Caley Hamilton Technique – Concepts of controllability and observability - Loss of controllability and observability due to sampling.

UNIT-V	DESIGN OF DIGITAL CONTROL	9

Digital PI, PD and PID Controller – Position and velocity forms –State regulator design – Design of state observers – Dead beat controller design by state feedback and Design of Dead beat observers.

Total Contact Hours	**:**	**45**

Course Outcomes:

At the end of the course the student will be able to:

- Understand the concept of basic digital control system

●	Acquire the concept of sampling and data reconstruction processes.
●	Utilize the knowledge on Z-Transforms to process time sequences.
●	Obtain the different types of companion forms and to analyze controllability and observability of a discrete system.
●	Design PID controllers, state regulator, state observer Dead beat controller and Dead beat observers.
Text Book (s):	
1	M.Gopal, 'Digital Control and State Variables Methods', Tata McGraw HILL, 2ndEdition, 2003.
2	B.C. Kuo, "Digital control systems", Second Edition, Oxford University press, 1992.
3	Katsuhiko Ogata, "Discrete-Time Control Systems", PHI, 1995.
4	Franklin, Powell, and Workman,"Digital Control of Dynamic Systems", Addison –Wesley,1998.
Reference Books(s) / Web links:	
1	P.B. Deshpande and R.H. Ash, 'Computer Process Control', ISA Publication, USA, 1995.
2	Ioan D. Landau and Gianluca Zito Digital Control Systems: Design, Identification and Implementation Springer-Verlag , 2006.
3	C.M. Houpis, G.B. Lamount, 'Digital Control Systems-Theory, Hardware, Software', International Student Edition, McGraw Hill Book Co., 1985.

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	3	3	-	2	1	-	3	-	2	3	3	3
CO 2	3	3	3	3	3	-	2	1	-	3	-	2	3	3	3
CO 3	3	3	3	3	3	-	2	1	-	3	-	2	3	3	3
CO 4	3	-	-	-	-	-	2	1	-	3	-	2	3	3	3
CO 5	3	-	-	-	-	-	2	1	-	3	-	2	3	3	3
Average	3	3	3	3	3	-	2	1	-	3	-	2	3	3	3

Subject Code	**Subject Name (Theory course)**	**Category**	**L**	**T**	**P**	**C**
EE23E13	**FUNDEMENTALS OF EMBEDDED SYSTEMS**	**PE**	**3**	**0**	**0**	**3**

Objectives:

- To introduce the building blocks of embedded system.
- To educate in various embedded development Strategies.
- To Introduce Bus Communication in processors, Input/output interfacing.
- To impart knowledge in various processor scheduling algorithms.
- To introduce Basics of Real time operating system and example tutorials to discuss on one real time operating system tool

UNIT-I	**INTRODUCTION TO EMBEDDED SYSTEMS**	**9**

Introduction to Embedded Systems – CyberPhysical Systems– The build process for embedded systems- Structural units in Embedded processor , selection of processor & memory devices- DMA –,Memory architectures- Memory management methods- Timer and Counting devices, Watchdog Timer, Real Time Clock, IDE, assembler, compiler, linker, simulator, debugger, In circuit emulator, Boundary Scan Target Hardware Debug.

UNIT-II	**EMBEDDED NETWORKING**	**9**

Embedded Networking: Introduction, I/O Device Ports & Buses– Serial Bus communication protocols - RS232 standard – RS422 – RS485 - CAN Bus -Serial Peripheral Interface (SPI) – Inter Integrated Circuits (I2C) –need for device drivers

UNIT-III	**EMBEDDED FIRMWARE DEVELOPMENT ENVIRONMENT**	**9**

Embedded Product Development Life Cycle- objectives, different phases of EDLC, Modelling of EDLC; issues in Hardware-software Co-design, Embedded Firmware Design approaches, Data Flow Graph, State machine model, Extended state machines, Sequential Program Model, Concurrent Model, Object oriented Model, Unified Modelling language.

UNIT-IV	**RTOS BASED EMBEDDED SYSTEM**	**9**

Introduction to basic concepts of RTOS- Task, process & threads, interrupt routines in RTOS, Multiprocessing and Multitasking, Task models, Preemptive and non-preemptive scheduling, Task communication shared memory, message passing-, Inter process Communication – synchronization between processes-semaphores, Mailbox, pipes, priority inversion, priority inheritance, comparison of Real time Operating systems: VxWorks, ЧC/OS-II, RT Linux

UNIT-V	**EMBEDDED SYSTEM APPLICATION DEVELOPMENT**	**9**

Case Study of Washing Machine- Automotive Application- Smart card System.			
	Total Contact Hours	**:**	**45**

Course Outcomes:	
●	describe the building blocks of embedded system.
●	explain various embedded development strategies.
●	illustrate to incorporate interface as Interrupt services.
●	discuss various processor scheduling algorithms
●	able to involve embedded concepts for developing automation applications.
Text Book (s):	
1	Shibu. K.V, "Introduction to Embedded Systems", Tata Mcgraw Hill,2009
2	Tammy Noergaard, "Embedded Systems Architecture", Elsevier, 2006.
Reference Books(s) / Web links:	
1	Jean Labrosse, "Embedded Systems Building Blocks: Complete and Ready-to-Use Modules in C", CRC Press, CRC Press; 2nd edition, 1999
2	Rajkamal, "Embedded System-Architecture, Programming, Design", McGraw Hill, 2013
3	Elicia White, "Making Embedded Systems", O' Reilly Series,SPD,2011.
4	Han-Way Huang, "Embedded system Design Using C8051", Cengage Learning, 2009.
5	Lyla B Das, "Embedded Systems-An Integrated Approach", Pearson, 2013
6	Peckol, "Embedded System Design", John Wiley & Sons, 2010
7	Rajib Mall, "Real-Time systems Theory and Practice" Pearson Education, 2007
8	Parag H.Dave,Himanshu B.Dave,"Embedded Systems-Concepts ,Design and Programming, Pearson Education,2015
9	https://www.youtube.com/watch?v=GfPcz1y0JoE

COs/POs&PSOs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO 1	1											2			
CO 2	1			1								2			
CO 3	1											2			
CO 4	1			1								2			
CO 5	1	2		1			1		1	1		2	1	1	3
Average	**1**	**0.4**	**0**	**0.6**	**0**	**0**	**0.2**	**0**	**0.2**	0.2	**0**	**2**	**0.2**	0.2	**0.6**

Course Code	**Course Title(Lab oriented Theory Course)**	**Category**	**L**	**T**	**P**	**C**
EE23E14	**PLC and SCADA**	**PE**	**2**	**0**	**2**	**3**

Objectives:	
●	To impart knowledge on the operation of PLC interfaced sensors and signal communication.
●	To familiarize on the architecture, operation and programming of Programmable Logic Controllers.
●	To provide knowledge on the basic features, different blocks used and its applications.
●	To teach the functioning of SCADA also to make the students to interface PLC with SCADA.
●	To introduce the students with various applications of PLC SCADA interfaced systems.

UNIT-I		**6**
Need and benefits of Automation, Tools of Automation: PLC, SCADA, HMI, DCS & Drives, PLC Architecture: Block diagram, working CPU: function, scanning cycle, speed of execution, Memory: organization and function, I/Os in PLC. Power supply: Block diagram, Working PLC Type: Fixed PLC, Modular PLC. 'Redundancy in PLC system Advantages and Disadvantages of PLC.		
UNIT-II		**6**
Discrete input modules:AC input modules - DC input modules - Analog input modules, Discrete output modules: AC output modules - DC output modules, Relay and Isolated o/p modules Analog output modules.		

UNIT-III		**6**
PLC I/O addressing, PLC programming Instructions: Relay type instructions, timer instructions: On delay, off delay, retentive, Counter instructions: Up, Down, High speed, Logical instructions. Comparison Instructions, Data handling Instructions, Ladder Logic Program: Motor sequence control, Traffic fight control, elevator control, Tank Level control, conveyor system.		
UNIT-IV		6
Introduction to SCADA, Application area of SCADA, SCADA architecture/block diagram, Benefits of SCADA.Types of SCADA:Single Master Single Remote, Single Master Multiple, Remote, Multiple Master Multiple Remote, SCADA System Hardware, Remote Terminal Units (RTUs), Master Terminal Units(MTUs) Communication system Differentiate SCADA and PLC		
UNIT-V		**6**
Interfacing SCADA system with PLC: Connection diagram, object linking and embedding for Process Control(OPC) architecture, Steps in Creating SCADA Screen for simple object, Steps for Linking SCADA object (defining Tags and items') with PLC ladder program using OPC		

	Contact Hours	**:**	**30**

List of Experiments	
1	Develop/Execute a ladder program for blinking of LEDs.
2	Develop/Execute a ladder program for sequential ON-OFF control of lamps.
3	Develop/ Execute ladder program for sequential control of DC motor.
4	Develop/ Execute ladder program for sequential control of DC motor .
5	Develop/ Execute ladder program for Traffic fight control system .
6	Develop and test ladder program for pulse counting using limit switch /Proximity sensor.
7	Develop/ Execute ladder program for temperature ON-OFF control.
8	Develop/ Execute ladder program for washing system.
9	Develop/ Execute ladder program for conveyor system.
10	Develop/ Execute ladder program for elevator system.

	Contact Hours	**:**	**15**
	Total Contact Hours	**:**	**45**

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

- Realise the function of different sensors and its output
- Realize the architecture of different PLCs and the type of modules
- Apply different blocks while programming
- Comprehend different features available with SCADA for monitoring and controlling purpose
- Analyse the applications of PLC & SCADA interface systems

Suggested Activities

- Do the internet survey and make a list of leading manufactures of the PLC, SCADA, with their brand name.
- Read an operating manual of the PLCs of reputed Manufactures.
- Download animated videos from the internet for any theory topic and make presentation on it.
- Prepare a list of available analog input /output devices, digital input /output devices available in the market.
- Prepare report on steps to be followed to configure available SCADA software.

Suggested Evaluation Methods

- Project Based Evaluation

Text Book (s):

1	Gary Dunning, "Introduction to Programmable Logic Controllers" Thomson Learning, 2001.
2	John Webb, Programmable Logic Controllers: Principles and Applications,5th edition Prentice Hall of India, 2012
3	Katariya Sanjay B , "Industrial Automation Solutions For Plc, Scada, Drive And Field Instruments: Easy To

Reference Books(s) :

1	Bolton, "Programmable Logic Controllers" 5 th Edition Newnes,2009
2	Parr, "Programmable Controllers: An Engineers Guide", 3rd Edition, Elsevier, Indian Reprint, 2013
3	Petruzella , "Programmable Logic Circuits" 4 th Edition, TATA Mcgraw hill, 2016
5	Programmable Logic Controller (Plc) Tutorial, Siemens Simatic S7-1200 by Stephen Philip Tubbs

Web links :	
1	https://cache.industry.siemens.com/dl/files/465/36932465/att_106119/v1/s71200_system_manual_en-US_en-US.pdf
2	https://www.youtube.com/@realpars

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	2	2	-	-	-	-	-	3	3	-	-	3	1	3
CO 2	3	2	3	-	-	-	-	2	3	1	-	-	2	1	3
CO 3	3	3	1	-	-	-	-	1	2	2	-	-	1	1	1
CO 4	2	2	2	-	-	-	-	3	1	2	-	1	3	3	1
CO 5	3	1	3	-	-	-	-	3	3	1	-	2	2	1	1
Average	2.8	2	2.2					2.25	2.4	1.8		1.5	2.2	1.4	1.8

Course Code	Course Title(Theory Course)	Category	L	T	P	C
EE23E15	Embedded Systems for Automobile Applications	PE	3	0	0	3

Course Objectives:

- To expose the students to the fundamentals and building of Electronic Engine Control systems.
- To teach on sensor functional components for vehicles.
- To discuss on programmable controllers for vehicles management systems.
- To teach logics of automation & communication techniques for vehicle communication.
- To introduce the infotainment system development.

UNIT-I	INTRODUCTION TO AUTOMOTIVE SYSTEMS	9

Overview of Automotive systems, fuel economy, air-fuel ratio, emission limits and vehicle performance; Electronic control Unit– open-source ECU.

UNIT-II	SENSORS AND ACTUATORS FOR AUTOMOTIVES	9

Review of automotive sensors- sensors interface to the ECU, Smart sensor and actuators for automotive applications- Simulation study of automotive sensors and actuators components

UNIT-III	VEHICLE MANAGEMENT SYSTEMS	9

Energy Management system -Adaptive cruise control - anti-locking braking system - Safety and Collision Avoidance.

UNIT-IV	ONBOARD DIAGONSTICS AND COMMUNICATION	9

OBD , Vehicle communication protocols- Bluetooth, CAN, LIN, FLEXRAY and MOST- CAN Connectivity in an Automotive Application using vehicle network toolbox

UNIT-V	RECENT TRENDS IN AUTOMOTIVE SYSTEMS	9

Navigation- Autonomous car- Role of IoT in Automotive systems- Battery Management system for EV batteries

Contact Hours	:	45

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

- Insight into the significance of the role of embedded system for automotive applications.
- Illustrate the need, selection of sensors and actuators and interfacing with ECU
- Develop the Embedded concepts for vehicle management and control systems.
- Demonstrate the need of Electrical vehicle and able to apply the embedded system technology for various aspects of EVs
- Improved Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in embedded systems design and its application in automotive systems.

Suggested Activities

- Mini project : Battery Management system for EV batteries.

Suggested Evaluation Methods

- Assignments / Mini Project

Text Book (s):

1	William B. Ribbens ,"Understanding Automotive Electronics", Elseiver,8th Edition, 2017

2	Jurgen, R., Automotive Electronics Hand Book, McGraw Hill, 2nd Edition, 1999
3	L.Vlacic,M.Parent,F.Harahima,"Intelligent Vehicle Technologies",SAE International, 2001, 1st Edition, 2017.
Reference Books(s) :	
1	ERENCES: 1. Ali Emedi, Mehrdedehsani, John M Miller , "Vehicular Electric power system- land, Sea, Air and Space Vehicles" Marcel Decker, 2004, 1st Edition
2	Jack Erjavec,JeffArias,"Alternate Fuel Technology-Electric ,Hybrid& Fuel Cell Vehicles",Cengage ,2012, 2nd Edition.
3	Electronic Engine Control technology – Ronald K Jurgen Chilton's guide to Fuel Injection – Ford 2nd Edition, 2004.
4	Automotive Electricals / Electronics System and Components, Tom Denton, 5th Edition, 2017.
5	Uwe Kiencke, Lars Nielsen, "Automotive Control Systems: For Engine, Driveline, and Vehicle", Springer; 1st Edition, 2005.
6	Automotive Electricals Electronics System and Components, Robert Bosch Gmbh, 5thEdition, 2014.
7	Automotive Hand Book, Robert Bosch, Bently Publishers, 10th Edition, 2018.
Web links :	
1	https://www.autosar.org/fileadmin/ABOUT/AUTOSAR_EXP_Introduction.pdf
2	https://microcontrollerslab.com/can-communication-protocol/
3	https://ackodrive.com/car-guide/different-types-of-car-sensors/
4	https://www.tomtom.com/blog/automated-driving/what-is-adaptive-cruise-control/
5	https://www.synopsys.com/automotive/what-is-autonomous-car.html

COs/POs&PSOs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO 1	1	3	2	2	1	-	-	-	-	-	-	-	2	1	3
CO 2	2	3	3	2	2	-	-	-	-	-	-	-	2	2	2
CO 3	3	3	3	3	3	-	-	-	-	-	-	-	2	1	3
CO 4	3	3	3	3	3	-	-	-	-	-	-	-	1	3	2
CO 5	3	3	1	2	1	-	-	-	1	-	-	-	2	2	3
Average	**2.4**	**3**	**2.4**	**2.4**	**2**	-	-	-	**1**	-	-	-	**1.8**	**1.8**	**2.6**

Course Code	**Course Title(Theory Course)**	**Category**	**L**	**T**	**P**	**C**
EE23E16	**EMBEDDED CONTROL FOR ELECTRIC DRIVES**	**PE**	**3**	**0**	**0**	**3**

Course Objectives:

- To provide knowledge on the control of electrical drives
- To emphasize the need for embedded system for controlling the electric drives
- To provide knowledge on control of electric drives using ARM and FPGA based processors,
- To impart knowledge on control of electric drives using optimization and machine learning based algorithms.
- To learn the control of electric drives using Fuzzy Logic, ANN and DNN based controllers.

UNIT-I **INTRODUCTION ELECTRICAL DRIVES**

Electric drive and its classifications, Four-quadrant drive, Dependence of load torque on various factors, Dynamics of motor-load combination-Solid State Controlled Drives-Machine learning and optimization techniques for electrical drives-Sensors and interface modules for Electric drives- IoT for Electrical drives applications.

UNIT-II **OVERVIEW OF EMBEDDED PROCESSOR**

Embedded Processor architecture-RTOS – Hardware/software co-design-Programming with SoC processors.

UNIT-III **INDUCTION MOTOR CONTROL**

Types- Speed control methods-PWM techniques- VSI fed three-phase induction motor- Fuzzy logic Based speed control for three phase induction motor-FPGA based three phase induction motor control.

UNIT-IV	BLDC MOTOR CONTROL	
Overview of BLDC Motor -Speed control methods -PWM techniques- ARM processor-based BLDC motor control- ANN for BLDC Motor control.		
UNIT-V	**SRM MOTOR CONTROL**	
Overview of SRM Motor -Speed control methods -PWM techniques- FPGA based SRM motor control- DNN for SRM Motor control.Introduction to electric components used in hybrid and electric vehicles,Configuration and control of Switch Reluctance Motor drives.		

Total Contact Hours	**:**	**45**

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

- interpret the significance of embedded control of electrical drives
- deliver insight into various control strategy for electrical drives.
- develop knowledge on Machine learning and optimization techniques for motor control.
- develop knowledge on control of electric drives using ARM and FPGA based processors
- develop knowledge on control of electric drives using Fuzzy Logic, ANN and DNN based controllers

Suggested Activities

- Seminars
- Quiz
- Guest Lectures

Suggested Evaluation Methods

- Assignments

Text Book (s):

1	R.Krishnan, "Electric Motor Drives – Modeling, Analysis and Control",Prentice-Hall of India Pvt. Ltd., New Delhi,2010.
2	VedamSubramanyam, "Electric Drives – Concepts and Applications", Tata McGraw- Hill publishing company Ltd., New Delhi, 2011
3	K. Venkataratnam ,Special Electrical Machines, Universities Press, 2014.

Reference Books(s) :

1	Steve Furber, 'ARM system on chip architecture', Addision Wesley,2010.
	Ron Sass and AnderewG.Schmidt, " Embedded System design with platform FPGAs: Principles and Practices", Elsevier, 2010.
3	Steve Kilts, "Advanced FPGA Design: Architecture, Implementation, and Optimization" Willey, 2007
4	Valery Vodovozov, "Electrical Drive: Performance, Design and Control" **Lap Lambert,2014**
5	Ebooks: Iqbal Husain, "Electric and Hybrid Vehicles Design Fundamentals" CRC Press, Boca Raton, Florida, USA,3rd Edition 2021

Web links :

1	https://www.intechopen.com/chapters/54887 - DC Drives
2	https://www.mathworks.com/videos/embedded-code-generation-for-ac-motor-controllers-81864.html - AC Drives

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	2	3	-	-	-	-	-	-	3	2	2	2
CO 2	3	3	1	2	-	-	-	-	-	-	-	3	3	2	2
CO 3	3	3	3	2	3	-	-	-	-	-	-	3	3	3	2
CO 4	3	3	3	2	3	-	-	-	-	-	-	3	3	3	2
CO 5	3	3	3	2	3	-	-	-	-	-	-	3	3	3	2
Average	**3**	**3**	**2.6**	**2**	**2.4**							**3**	**2.8**	**2.6**	**2**