ANNA UNIVERSITY, CHENNAI

UNDERGRADUATE CURRICULUM (UNIVERSITY DEPARTMENTS)

Campus: CEG

Department: Electrical and Electronics Engineering

Programme: B.E. Electrical and Electronics Engineering

Regulations: 2023 (Revised 2024), with effect from the AY 2024 – 25 to all the students of UG Programme.

OVERVIEW OF CREDITS

Sem	PCC	PEC	ESC	HSMC	ETC	OEC	SDC	UC	SLC	IOC	Total
I	-	-	8	11	-	-	4	1			24
II	-	-	7	11	-	-	3	1			22
III	16	-	-	4	-	-	2	2			24
IV	16	-	4	-	4		2				26
V	17	3	-	-	-	-		3	1	1	25
VI	8	6	-	-	-	3	2	3		1	23
VII	4	9	-	-	4	3		1		1	22
VIII	-	-	-	-	-	-	8				8
Total	61	18	18	26	8	6	18	11	1	3	174
% of Category	35.9 %	10.6 %	10.6 %	15.29 %	4.7 %	3.5 %	10.6 %	6.5 %	0.6%	1.76 %	100

CATEGORY OF COURSES

PCC – Professional Core Course
PEC – Professional Elective Course Course
ETC – Emerging Technology Course
OEC – Open Elective Course
SLC – Self Learning Course
ESC – Engineering Science Course
HSMC – Humanities Science and Management
SDC – Skill Development Course
UC – University Course
IOC – Industry Oriented Course

For Honours & Minor Degree, please refer the Regulations 2023 (Revised 2024).

Semester – I							
S. No.	Course Code	Course Name	Course Type#	Periods / Week		Credits	Category
				L-T-P	TCP*		
1	EN23C01	Foundation English	LIT	2-0-2	4	3	HSMC
2	MA23C01	Matrices and Calculus	T	3-1-0	4	4	HSMC
3	PH23C01	Engineering Physics	LIT	3-0-2	5	4	HSMC
4	ME23C01	Engineering Drawing and 3D modeling	LIT	2-0-4	6	4	SDC
5	ME23C05	Basics of Mechanical Engineering	T	2-0-0	2	2	ESC
6	CE23C03	Basic Civil Engineering	T	2-0-0	2	2	ESC
7	UC23H01	தமிழர்மரபு/ Heritage of Tamils	T	1-0-0	1	1	UC
8	CS23C04	Programming in C	LIT	2-0-4	6	4	ESC
9		NCC/NSS/NSO/YRC	-	0-0-2	2	-	UC
					Total Credits	**24**	

*** TCP –** Total Contact Period(s)

#**TYPE OF COURSE**

LIT – Laboratory Integrated Theory
T – Theory
L – Laboratory Course
IPW – Internship cum Project Work
PW – Project Work
CDP – Capstone Design Project

Semester – II							
S. No.	Course Code	Course Name	Course Type#	Periods / Week		Credits	Category
				L-T-P	TCP*		
1	EN23C02	Professional Communication	LIT	2-0-2	4	3	HSMC
2	MA23C02	Ordinary Differential Equations and Transform Techniques	T	3-1-0	4	4	HSMC
3	CY23C01	Engineering Chemistry	LIT	3-0-2	5	4	HSMC
4	PH23C10	Electronic Properties of Materials	T	3-0-0	3	3	ESC
6	ME23C03	Engineering Mechanics	T	3-1-0	4	4	ESC
7	UC23H02	தமிழரும் தொழில்நுட்பமும் / Tamils and Technology	T	1-0-0	1	1	UC
8	ME23C04	Makerspace	LIT	1-0-4	5	3	SDC
9		Audit Course -I	-	-	-	-	UC
					Total Credits	**22**	

SEMESTER – III							
S. NO.	COURSE CODE	COURSE NAME	COURSE TYPE#	PERIODS / WEEK		CREDITS	CATE GORY
				L-T-P	TCP*		
1	MA23C03	Linear Algebra and Numerical Methods	T	3-1-0	4	4	HSMC
2	EE23301	Electrical Circuit Analysis	LIT	3-0-2	5	4	PCC
3	EE23302	Electromagnetic Theory	LIT	3-0-2	5	4	PCC
4	EE23303	Digital Electronics	LIT	3-0-2	5	4	PCC
5	EE23304	Analog Electronics	LIT	3-0-2	5	4	PCC
6		Skill Development Course I	-	-	-	2	SDC
7	UC23U01	Universal Human Values	LIT	1-0-2	3	2	UC
					TOTAL CREDITS	**24**	

SEMESTER – IV							
S. NO.	**COURSE CODE**	**COURSE NAME**	**COURSE TYPE#**	**PERIODS / WEEK**		**CREDITS**	**CATE GORY**
				L-T-P	**TCP***		
1	EE23401	Signal and Systems for Electrical Engineers	LIT	3-0-2	5	4	ESC
2	EE23402	Electrical Machines - I	T	3-0-0	3	3	PCC
3	EE23403	Measurement and Instrumentation	LIT	3-0-2	5	4	PCC
4	EE23404	Microprocessors and Microcontrollers	LIT	3-0-2	5	4	PCC
5	EE23405	Transmission and Distribution	T	3-0-0	3	3	PCC
6		Emerging Technology Course I	LIT	3-0-2	5	4	ETC
7		Skill Development Course II	-	-	-	2	SDC
8		Audit Course-II	-	-	-	-	UC
9	EE23406	Electrical Machines Laboratory – I	L	0-0-4	4	2	PCC
					TOTAL CREDITS	**26**	

SEMESTER – V (PREFERENCE FOR FOREIGN EXCHANGE)							
S. NO.	**COURSE CODE**	**COURSE NAME**	**COURSE TYPE#**	**PERIODS / WEEK**		**CREDITS**	**CATE GORY**
				L-T-P	**TCP***		
1	EE23501	Electrical Machines – II	T	3-0-0	3	3	PCC
2	EE23502	Control Systems Design	LIT	3-0-2	5	4	PCC
3	EE23503	Power System Analysis	LIT	3-0-2	5	4	PCC
4	EE23504	Power Electronics	LIT	3-0-2	5	4	PCC
5		Professional Elective – I	T	3-0-0	3	3	PEC
6		Industry Oriented Course – I	T	1-0-0	1	1	IOC
7	UC23E01	Engineering Entrepreneurship Development	T	2-0-2	4	3	UC
8	EE23L01	Self-Learning Course	T	1-0-0	1	1	SLC
9	EE23505	Electrical Machines Laboratory – II	L	0-0-4	4	2	PCC
					Total Credits	**25**	
COURSES FOR HONOURS DEGREE							
S. NO.	**COURSE CODE**	**COURSE NAME**	**COURSE TYPE#**	**PERIODS / WEEK**		**CREDITS**	**CATE GORY**
				L-T-P	**TCP***		
1.	EE23D01	Capstone Design Project – Level I	CDP	0-0-12	12	6	SDC

(OR)							
1.		Honours Elective – I	T			3	
2.		Honours Elective – II	T			3	
COURSES FOR MINOR DEGREE(OFFERED JOINTLY WITH MECHANICAL ENGINEERING)							
S. NO.	**COURSE CODE**	**COURSE NAME**	**COURSE TYPE#**	**PERIODS / WEEK**		**CREDITS**	**CATE GORY**
				L-T-P	**TCP***		
1.		Minor Elective – I	T			3	PEC
2.		Minor Elective – II	T			3	PEC

SEMESTER – VI (PREFERENCE FOR FOREIGN EXCHANGE)							
S. NO.	**COURSE CODE**	**COURSE NAME**	**COURSE TYPE#**	**PERIODS / WEEK**		**CREDITS**	**CATE GORY**
				L-T-P	**TCP***		
1	EE23601	Power System Operation and Control	LIT	3-0-2	5	4	PCC
2	EE23602	Protection and Switchgear	LIT	3-0-2	5	4	PCC
3	EE23U02	Sustainable Development – Electrical Engineering	T	2-0-2	4	3	UC
4		Professional Elective – II	T	3-0-0	3	3	PEC
5		Professional Elective – III	T	3-0-0	3	3	PEC
6		Open Elective – I	T	3-0-0	3	3	OEC
7		Skill Development Course – III	-	-	-	2	SDC
8		Industry Oriented Course – II	-	-	-	1	IOC
TOTAL CREDITS						**23**	
COURSES FOR HONOURS DEGREE							
S. NO.	**COURSE CODE**	**COURSE NAME**	**COURSE TYPE#**	**PERIODS / WEEK**		**CREDITS**	**CATE GORY**
				L-T-P	**TCP***		
1.	EE23D02	Capstone Design Project – Level II	CDP	0-0-12	12	6	SDC
(OR)							
1.		Honours Elective – III	T			3	
2.		Honours Elective – IV	T			3	
COURSES FOR MINOR DEGREE							
S. NO.	**COURSE CODE**	**COURSE NAME**	**COURSE TYPE#**	**PERIODS / WEEK**		**CREDITS**	**CATE GORY**
				L-T-P	**TCP***		
1.		Minor Elective – III	T			3	PEC
2.		Minor Elective – IV	T			3	PEC

SEMESTER – VII							
S. NO.	COURSE CODE	COURSE NAME	COURSE TYPE#	PERIODS / WEEK		CREDITS	CATE GORY
				L-T-P	TCP*		
1	EE23701	High Voltage Engineering	LIT	3-0-2	5	4	PCC
2		Emerging Technology Course II	LIT	3-0-2	5	4	ETC
3		Professional Elective – IV	T	3-0-0	3	3	PEC
4		Professional Elective – V	T	3-0-0	3	3	PEC
5		Professional Elective – VI	T	3-0-0	3	3	PEC
6		Open Elective – II	T	3-0-0	3	3	OEC
7		Industry Oriented Course – III	-	-	-	1	IOC
8	EE23U01	Standards - Electrical Engineering	T	1-0-0	1	1	UC
					TOTAL CREDITS	22	
COURSES FOR HONOURS DEGREE							
S. NO.	COURSE CODE	COURSE NAME	COURSE TYPE#	PERIODS / WEEK		CREDITS	CATE GORY
				L-T-P	TCP*		
1.	EE23D03	Capstone Design Project – Level III	CDP	0-0-12	12	6	SDC
		(OR)					
1.		Honours Elective – V	T			3	
2.		Honours Elective – VI	T			3	
COURSES FOR MINOR DEGREE							
S. NO.	COURSE CODE	COURSE NAME	COURSE TYPE#	PERIODS / WEEK		CREDITS	CATE GORY
				L-T-P	TCP*		
1.		Minor Elective – V	T			3	PEC
2.		Minor Elective – VI	T			3	PEC

SEMESTER – VIII							
S. NO.	COURSE CODE	COURSE NAME	COURSE TYPE#	PERIODS / WEEK		CREDITS	CATE GORY
				L -T-P	TCP*		
1.	EE23801	Project Work / Internship cum Project Work	PW	0-0-16	16	8	SDC
					TOTAL CREDITS	8	

TOTAL NUMBER OF CREDITS:174

PROFESSIONAL ELECTIVE COURSES (PEC) VERTICALS				
VERTICAL I	**VERTICAL II**	**VERTICAL III**	**VERTICAL IV**	**VERTICAL V**
POWER ENGINEERING	**CONVERTERS AND DRIVES**	**EMBEDDED SYSTEMS**	**ELECTRIC VEHICLE TECHNOLOGY**	**MODERN CONTROL AND INDUSTRIAL AUTOMATION**
Utilization and Conservation of Electrical Energy	Electrical Machines-III	Embedded C- Programming	Electric Vehicle Architecture and Dynamics	Industrial Automation Systems
Substation Engineering and Automation	Analysis of Electrical Machines	Embedded Processors	Electric Vehicle Design, Modelling and Control	Robotics And Automation
HVDC and FACTS	Multilevel Level Power Converters	Embedded Control for Electric Drives	Design of Electric Vehicle Charging System	Model Based Control
Energy Management and Auditing	Electrical Drives	Smart System Automation	Testing of Electric Vehicles	Non-Linear Control
Power System Transients	SMPS and UPS	Embedded System for Automotive Applications	Grid Integration of Electric Vehicles	System Identification
Smart Grid	Power Electronics for Renewable Energy Systems	VLSI Design	Energy Storage Systems	Adaptive Control
Restructured Power Market	Control of Power Electronics Circuits	Digital Signal Processing	-	Process Modeling and Simulation
Sustainable HV Insulation System	Power Quality	Big Data Analytics	-	Computer Control of Processes
-	-	-	-	

Registration of Professional Elective Courses from Verticals:

Professional Elective Courses will be registered from Semesters IV to VII. These courses are listed in groups called verticals that represent a particular area of specialization / diversified group. Students are permitted to choose all the Professional Electives from a particular vertical or from different verticals. Further, only one Professional Elective course shall be chosen in a semester horizontally (row-wise). However, more than one course is permitted from the same row, provided each course is enrolled in Semester IV/VI and another in semester V/VII.

The registration of courses for B.E./B.Tech (Hons) shall be done from Semester V to VIII. The procedure for registration of courses explained above shall be followed for the courses of B.E/B.Tech (Hons) also. For more details on B.E./B.Tech (Hons) or Minor degree refer to the Regulations 2023, Clause 4.11.

VERTICAL I: POWER ENGINEERING						
S. NO.	COURSE CODE	COURSE NAME	COURSE TYPE#	PERIODS / WEEK		CREDITS
				L-T-P	TCP*	
1	EE23001	Utilization and Conservation of Electrical Energy	T	3-0-0	3	3
2	EE23002	Substation Engineering and Automation	T	3-0-0	3	3
3	EE23003	HVDC and FACTS	T	3-0-0	3	3
4	EE23004	Energy Management and Auditing	T	3-0-0	3	3
5	EE23005	Power System Transients	T	3-0-0	3	3
6	EE23006	Smart Grid	T	3-0-0	3	3
7	EE23007	Restructured Power Market	T	3-0-0	3	3
8	EE23008	Sustainable HV Insulation System	T	3-0-0	3	3

VERTICAL II- CONVERTERS AND DRIVES						
S. NO.	COURSE CODE	COURSE NAME	COURSE TYPE#	PERIODS / WEEK		CREDITS
				L-T-P	TCP*	
1	EE23009	Electrical Machines-III	T	3-0-0	3	3
2	EE23010	Analysis of Electrical Machines	T	3-0-0	3	3
3	EE23011	Multilevel Power Converters	T	3-0-0	3	3
4	EE23012	Electrical Drives	T	3-0-0	3	3
5	EE23013	SMPS and UPS	T	3-0-0	3	3
6	EE23014	Power Electronics for Renewable Energy Systems	T	3-0-0	3	3
7	EE23015	Control of Power Electronics Circuits	T	3-0-0	3	3
8	EE23016	Power Quality	T	3-0-0	3	3

VERTICAL III- EMBEDDED SYSTEMS						
S. NO.	COURSE CODE	COURSE NAME	COURSE TYPE#	PERIODS / WEEK		CREDITS
				L-T-P	TCP*	
1	EE23017	Embedded C- Programming	T	3-0-0	3	3
2	EE23018	Embedded Processors	T	3-0-0	3	3
3	EE23019	Embedded Control for Electric Drives	T	3-0-0	3	3
4	EE23020	Smart System Automation	T	3-0-0	3	3
5	EE23021	Embedded System for Automotive Applications	T	3-0-0	3	3
6	EE23022	VLSI Design	T	3-0-0	3	3
7	EE23023	Digital Signal Processing	T	3-0-0	3	3
8	EE23024	Big Data Analytics	T	3-0-0	3	3

VERTICAL IV- ELECTRIC VEHICLE TECHNOLOGY						
S. NO.	COURSE CODE	COURSE NAME	COURSE TYPE#	PERIODS / WEEK		CREDITS
				L-T-P	TCP*	
1	EE23025	Electric Vehicle Architecture and Dynamics	T	3-0-0	3	3
2	EE23026	Electric Vehicle Design, Modelling and Control	T	3-0-0	3	3
3	EE23027	Design of Electric Vehicle Charging System	T	3-0-0	3	3
4	EE23028	Testing of Electric Vehicles	T	3-0-0	3	3
5	EE23029	Grid Integration of Electric Vehicles	T	3-0-0	3	3
6	EE23030	Energy Storage Systems	T	3-0-0	3	3

VERTICAL V- MODERN CONTROL AND INDUSTRIAL AUTOMATION						
S. NO.	COURSE CODE	COURSE NAME	COURSE TYPE#	PERIODS / WEEK		CREDITS
				L-T-P	TCP*	
1	EE23031	Industrial Automation Systems	T	3-0-0	3	3
2	EE23032	Robotics And Automation	T	3-0-0	3	3
3	EE23033	Model Based Control	T	3-0-0	3	3
4	EE23034	Non Linear Control	T	3-0-0	3	3
5	EE23035	System Identification	T	3-0-0	3	3
6	EE23036	Adaptive Control	T	3-0-0	3	3
7	EE23037	Process Modeling and Simulation	T	3-0-0	3	3
8	EE23038	Computer Control of Processes	T	3-0-0	3	3

MINOR ELECTIVES

(Offered jointly by Department of Electrical and Electronics Engineering and Department of Mechanical Engineering)

S. NO.	COURSE CODE	COURSE NAME	COURSE TYPE#	PERIODS / WEEK		CREDITS
				L-T-P	TCP*	
1	EE23039	* Power Electronics for Electric Vehicles	T	3-0-0	3	3
2	EE23040	* Applied Thermodynamics	T	3-0-0	3	3
3	EE23041	* Electrical Machines and Drives	T	3-0-0	3	3
4	EE23042	Control System Design for Electric Vehicle Applications	T	3-0-0	3	3
5	EE23043	Electric Vehicle Architecture	T	3-0-0	3	3
6	EE23044	Design of Hybrid Electric Vehicles	T	3-0-0	3	3
7	EE23045	Energy Storage Devices for Hybrid Electric Vehicles	T	3-0-0	3	3
8	EE23046	Electric Vehicle Charging Systems	T	3-0-0	3	3

*Mandatory Courses (Candidate has to enroll the subjects compulsorily)

EMERGING TECHNOLOGY COURSES (ETC)

S. NO.	COURSE CODE	COURSE NAME	COURSE TYPE#	PERIODS / WEEK		CREDITS
				L-T-P	TCP*	
1	EE23E01	AI and ML Fundamentals	LIT	3-0-2	5	4
2	EE23E02	Electrical Machine Design for EV	LIT	3-0-2	5	4
3	EE23E03	Sustainable Electrification for Remote Communities	LIT	3-0-2	5	4
4	EE23E04	Embedded System Design	LIT	3-0-2	5	4
5	EE23E05	MEMS and NEMS	LIT	3-0-2	5	4

OPEN ELECTIVE COURSE-OEC

S. NO.	COURSE CODE	COURSE NAME	COURSE TYPE#	PERIODS / WEEK		CREDITS
				L-T-P	TCP*	
1	EE23901	Introduction to Control System	T	3-0-0	3	3
2	EE23902	Electrical Vehicle Technologies	T	3-0-0	3	3
3	EE23903	Introduction to Embedded Systems	T	3-0-0	3	3

SKILL DEVELOPMENT COURSES

S. NO.	COURSE CODE	COURSE NAME	COURSE TYPE#	PERIODS / WEEK			CREDITS
				L	T	P	
1.	EE23S01	Programmable Logic Controller Laboratory	SDC	0	0	2	1
2.	EE23S02	Simulation Tools for Power System Studies	SDC	0	0	2	1
3.	EE23S03	Electrical Vehicles Powertrain Simulation	SDC	0	0	2	1
4.	EE23S04	Processors For Motor Control Application	SDC	0	0	2	1

EN23C01 **FOUNDATION ENGLISH** **L T P C**
2 0 2 3

COURSE OBJECTIVES:

- To develop students' foundational skills in reading, writing, grammar and vocabulary to enable them to understand and produce various forms of communication.
- To enhance students' proficiency in reading comprehension, narrative and comparative writing.
- To comprehend and analyse descriptive texts and visual images
- To articulate similarities and differences in oral and written forms.
- To improve students' proficiency in reading and writing formal letters and emails.

UNIT I BASICS OF COMMUNICATION **6**

Reading - Telephone message, bio-note; Writing – Personal profile; Grammar – Simple present tense, Present continuous tense, wh-questions, indirect questions; Vocabulary – Word formation (Prefix and Suffix).

LAB ACTIVITY: **6**

Listening – Telephone conversation; Speaking Self-introduction; Telephone conversation – Video conferencing etiquette

UNIT II NARRATION **6**

Reading – Comprehension strategies - Newspaper Report, An excerpt from an autobiography; Writing – Narrative Paragraph writing (Event, personal experience etc.); Grammar – Subject-verb agreement, Simple past, Past continuous Tenses; Vocabulary – One-word substitution

LAB ACTIVITY: **6**

Listening – Travel podcast; Speaking – Narrating and sharing personal experiences through a podcast

UNIT III DESCRIPTION **6**

Reading – A tourist brochure, Travel blogs, descriptive article/excerpt from literature, visual images; Writing –Descriptive Paragraph writing, Grammar – Future tense, Perfect tenses, Preposition; Vocabulary – Descriptive vocabulary

LAB ACTIVITY: **6**

Listening – Railway / Airport Announcements, Travel Vlogs; Speaking – Describing a place or picture description

UNIT IV COMPARE AND CONTRAST **6**

Reading – Reading and comparing different product specifications - Writing – Compare and Contrast Essay, Coherence and cohesion; Grammar – Degrees of Comparison; Vocabulary – Transition words (relevant to compare and contrast)

LAB ACTIVITY: **6**

Listening – Product reviews, Speaking – Product comparison based on product reviews - similarities and differences

UNIT V EXPRESSION OF VIEWS 6

Reading – Formal letters, Letters to Editor ; Writing – Letter writing/ Email writing (Enquiry / Permission, Letter to Editor); Grammar – Compound nouns, Vocabulary – Synonyms, Antonyms

LAB ACTIVITY: 6

Listening – Short speeches; Speaking – Making short presentations (JAM)

TOTAL: 60 PERIODS

TEACHING METHODOLOGY

Interactive lectures, role plays, group discussions, listening and speaking labs, technology enabled language teaching, flipped classroom.

EVALUATION PATTERN

Internal Assessment
- Written assessments
- Assignment

Lab assessment
- Listening
- Speaking

External Assessment
- End Semester Examination

LEARNING OUTCOMES

By the end of the courses, students will be able to

- Use appropriate grammar and vocabulary to read different types of text and converse appropriately.
- Write coherent and engaging descriptive and comparative essay writing.
- Comprehend and interpret different kinds of texts and audio visual materials
- Critically evaluate reviews and articulate similarities and differences
- Write formal letters and emails using appropriate language structure and format

TEXT BOOKS:

1. “English for Engineers and Technologists” Volume I by Orient Blackswan, 2022
2. “English for Science & Technology - I” by Cambridge University Press, 2023

REFERENCES

1. “Interchange” by Jack C.Richards, Fifth Edition, Cambridge University Press, 2017.
2. “English for Academic Correspondence and Socializing” by Adrian Wallwork, Springer, 2011.
3. “The Study Skills Handbook” by Stella Cortrell, Red Globe Press, 2019
4. www.uefap.com

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										√		√
CO2										√		
CO3										√		√
CO4										√		
CO5										√		√

MA23C01	MATRICES AND CALCULUS	L	T	P	C
		3	1	0	4

OBJECTIVES:

- To develop the use of matrix algebra techniques in solving practical problems.
- To familiarize the student with functions of several variables.
- To solve integrals by using Beta and Gamma functions.
- To acquaint the student with mathematical tools needed in evaluating multiple integrals.
- To acquaint the students with the concepts of vector calculus which naturally arise in many engineering problems.

UNIT I MATRICES **9+3**

Eigenvalues and Eigenvectors of a real matrix – Properties of Eigenvalues and Eigenvectors- Cayley-Hamilton theorem (excluding proof) – Diagonalization of matrices - Reduction of Quadratic form to canonical form by using orthogonal transformation - Nature of a Quadratic form.

UNIT II FUNCTIONS OF SEVERAL VARIABLES **9+3**

Limit, continuity, partial derivatives – Homogeneous functions and Euler's theorem - Total derivative – Differentiation of implicit functions – Jacobians -Taylor's formula for two variables - Errors and approximations – Maxima and Minima of functions of two variables – Lagrange's method of undermined multipliers.

UNIT III INTEGRAL CALCULUS **9+3**

Improper integrals of the first and second kind and their convergence – Differentiation under integrals - Evaluation of integrals involving a parameter by Leibnitz rule – Beta and Gamma functions-Properties – Evaluation of single integrals by using Beta and Gamma functions..

UNIT IV MULTIPLE INTEGRALS **9+3**

Double integrals – Change of order of integration – Double integrals in polar coordinates – Area enclosed by plane curves – Triple integrals – Volume of Solids – Change of variables in double and triple integrals-
Evaluation of double and triple integrals by using Beta and Gamma functions.

UNIT V VECTOR CALCULUS **9+3**

Gradient of a scalar field, directional derivative – Divergence and Curl – Solenoidal and Irrotational vector fields - Line integrals over a plane curve - Surface integrals – Area of a curved surface – Volume Integral - Green's theorem, Stoke's and Gauss divergence theorems (without proofs)– Verification and applications in evaluating line, surface and volume integrals.

TOTAL: 60 PERIODS

Laboratory based exercises / assignments / assessments will be given to students wherever applicable from the content of the course.

General engineering applications / branch specific applications from the content of each units wherever possible will be introduced to students.

Suggested Laboratory based exercises / assignments / assessments :

Matrices

1. Finding eigenvalues and eigenvectors
2. Verification of Cayley-Hamilton theorem
3. Eigenvalues and Eigenvectors of similar matrices
4. Eigenvalues and Eigenvectors of a symmetric matrix
5. Finding the powers of a matrix
6. Quadratic forms

Functions of Several Variables

1. Plotting of curves and surfaces
2. Symbolic computation of partial and total derivatives of functions

Integral Calculus

1. Evaluation of beta and gamma functions
2. Computation of error function and its complement

Multiple Integrals

1. Plotting of 3D surfaces in Cartesian and Polar forms

Vector Calculus

1. Computation of Directional derivatives
2. Computation of normal and tangent to the given surface

OUTCOMES:

CO 1 :Use the matrix algebra methods for solving practical problems.
CO 2 :Use differential calculus ideas on several variable functions.
CO 3 :Apply different methods of integration in solving practical problems by using Beta and Gamma functions.
CO 4 :Apply multiple integral ideas in solving areas and volumes problems.
CO 5 :Apply the concept of vectors in solving practical problems.

TEXT BOOKS:

1. Joel Hass, Christopher Heil, Maurice D.Weir "'Thomas' Calculus", Pearson Education., New Delhi, 2018.
2. Grewal B.S., "Higher Engineering Mathematics", Khanna Publishers, 45th Edition, New Delhi, 2020.
3. James Stewart, Daniel K Clegg & Saleem Watson "Calculus with Early Transcendental Functions", Cengage Learning, 6th Edition, New Delhi,2023.

REFERENCES:

1. Erwin Kreyszig, "Advanced Engineering Mathematics", 10th Edition, Wiley India Pvt Ltd., New Delhi, 2018.
2. Greenberg M.D., "Advanced Engineering Mathematics", Pearson Education2nd Edition, 5th Reprint, Delhi, 2009.
3. Jain R.K. and Iyengar S.R.K., "Advanced Engineering Mathematics",Narosa Publications, 5th Edition, New Delhi, 2017.
4. Narayanan S. and Manicavachagom Pillai T. K., "Calculus" Volume I and II, S. Viswanathan Publishers Pvt. Ltd., Chennai, 2009.
5. Peter V.O'Neil, "Advanced Engineering Mathematics", Cengage Learning India Pvt., Ltd, 7 th Edition, New Delhi , 2012.
6. Ramana B.V., "Higher Engineering Mathematics", Tata McGraw Hill Co. Ltd., 11th Reprint, New Delhi, 2010.

CO – PO Mapping:

Course Outcomes	PROGRAMME OUTCOMES											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**P10**	**P11**	**P12**
CO1 :	3	3	2	3	1	2	1	1	1	1	1	3
CO2 :	3	3	2	3	1	2	1	1	1	1	1	3
CO3 :	3	3	2	3	1	2	1	1	1	1	1	3
CO4 :	3	3	2	3	1	2	1	1	1	1	1	3
CO5 :	3	3	2	3	1	2	1	1	1	1	1	3

PH23C01 **ENGINEERING PHYSICS** **L T P C**

(Common to all branches of B.E/B.Tech Programmes) **3 0 2 4**

COURSE OBJECTIVES

- To familiarize with crystal structure, bonding and crystal growth.
- To impart knowledge on Mechanics of Materials.
- To impart knowledge of oscillations, sound and Thermal Physics
- To facilitate understanding of optics and its applications, different types of Lasers and fiber optics.
- To introduce the basics of Quantum Mechanics and its importance.

UNIT I CRYSTAL PHYSICS **9+6**

Crystal Bonding – Ionic – covalent – metallic and van der Walls's/ molecular bonding. Crystal systems - unit cell, Bravais lattices, Miller indices - Crystal structures - atomic packing density of BCC, FCC and HCP structures. NaCl, Diamond, Graphite, Graphene, Zincblende and Wurtzite structures - crystal imperfections- point defects - edge and screw dislocations – grain boundaries. Crystal Growth – Czocharalski method – vapor phase epitaxy – Molecular beam epitaxy- Introduction to X-Ray Diffractometer.

1. Determination of Lattice parameters for crystal systems.
2. Crystal Growth – Slow Evaporation method
3. Crystal Growth Sol – Gel Method

UNIT II MECHANICS OF MATERIALS **9+6**

Rigid Body – Centre of mass – Rotational Energy - Moment of inertia (M.I)- Moment of Inertia for uniform objects with various geometrical shapes. Elasticity –Hooke's law - Poisson's ratio - stress-strain diagram for ductile and brittle materials – uses- Bending of beams – Cantilever - Simply supported beams - uniform and non-uniform bending - Young's modulus determination - I shaped girders –Twisting couple – Shafts. Viscosity – Viscous drag – Surface Tension.

1. Non-uniform bending -Determination of Young's modulus of the material of the beam.
2. Uniform bending -Determination of Young's modulus of the material of the beam
3. Viscosity – Determination of Viscosity of liquids.

UNIT III OSCILLATIONS, SOUND AND THERMAL PHYSICS **9+6**

Simple harmonic motion - Torsional pendulum –- Damped oscillations –Shock Absorber -Forced oscillations and Resonance –Applications of resonance.- Waves and Energy Transport –Sound waves – Intensity level – Standing Waves - Doppler effect and its applications - Speed of blood flow. Ultrasound – applications - Echolocation and Medical Imaging. Thermal Expansion – Expansion joints – Bimetallic strip – Seebeck effect – thermocouple -Heat Transfer Rate – Conduction – Convection and Radiation.

1. Torsional pendulum-Determination of rigidity modulus of wire and moment of inertia of the disc
2. Melde's string experiment - Standing waves.
3. Ultrasonic interferometer – determination of sound velocity and liquids compressibility

UNIT IV OPTICS AND LASERS **9+6**

Interference - Thin film interference - Air wedge- Applications -Interferometers–Michelson Interferometer -– Diffraction - CD as diffraction grating – Diffraction by crystals -Polarization - polarizers -– Laser – characteristics – Spontaneous and Stimulated emission- population – inversion - Metastable states - optical feedback - Nd-YAG laser, CO_2 laser, Semiconductor laser - Industrial and medical applications - Optical Fibers – Total internal reflection – Numerical aperture and acceptance angle – Fiber optic communication – Fiber sensors – Fiber lasers.

1. Laser - Determination of the width of the groove of the compact disc using laser.
   Laser Parameters
   Determination of the wavelength of the laser using grating
2. Air wedge -Determination of the thickness of a thin sheet/wire
3. Optical fibre - Determination of Numerical Aperture and acceptance angle
   -Determination of bending loss of fibre.
4. Michelson Interferometer (Demonstration)

UNIT V QUANTUM MECHANICS 9+6

Black body radiation (Qualitative) – Planck's hypothesis – Einstein's theory of Radiation - Matter waves–de Broglie hypothesis - Electron microscope – Uncertainty Principle – The Schrodinger Wave equation (time-independent and time-dependent) – Meaning and Physical significance of wave function - Normalization - Particle in an infinite potential well-particle in a three-dimensional box - Degenerate energy states - Barrier penetration and quantum tunneling - Tunneling microscope.

1. Photoelectric effect – Determination of Planck's constant.
2. Black Body Radiation (Demonstration)
3. Electron Microscope (Demonstration)

TOTAL: 75 PERIODS

COURSE OUTCOMES:

After completion of the course, the students will be able to

CO1: Understand the significance of crystal structure and bonding. Learn to grow crystals.
CO2: Obtain knowledge on important mechanical and thermal properties of materials and determine them through experiments.
CO3: Conceptualize and visualize the oscillations and sound.
CO4: Grasp optical phenomenon and their applications in real life.
CO5: Appreciate and evaluate the quantum phenomenon.
CO6 Develop skill set to solve engineering problems and design experiments.

TEXT BOOKS:

1. Raymond A. Serway, John W. Jewett, Physics for Scientists and Engineers, Thomson Brooks/Cole, 2013.
2. D. Halliday, R. Resnick and J. Walker, Principles of Physics. John Wiley & Sons, 10th Edition, 2015.
3. N. Garcia, A. Damask and S. Schwarz, Physics for Computer Science Students, Springer-Verlag, 2012.
4. Alan Giambattista, Betty McCarthy Richardson and Robert C. Richardson, College Physics, McGraw-Hill Higher Education, 2012.

REFERENCES:

1. R. Wolfson, Essential University Physics. Volume 1 & 2. Pearson, 2016.
2. D. Kleppner and R. Kolenkow. An Introduction to Mechanics, McGraw Hill Education, 2017.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1		1							
CO2	3	2	1	1								
CO3	3	2	1	1								
CO4	3	2	1	1	1							
CO5	3	2	1	1	1							
CO6	3	2	1	2								

ME23C01	ENGINEERING DRAWING AND 3D MODELING	L	T	P	C
		2	0	4	4

INTRODUCTION

Manual drawing tools (Mini Drafter, Set Squares, Protractor, Compass, and different grades of pencil). **'**BIS' specifications and rules of Engineering Drawing – Arrows (2H thin line body, HB Filled head and L:W = 3:1 ratio), lettering (Digital fonts, font sizes pertaining to usage and representation), types of line and their syntax (Drawing based – Continuous thin & thick, dashed, dashed dotted and Application based – extension, dimensioning, construction, projection, reference, axis, section, hatching, and break lines), scaling (up, down and equal), and dimensioning. Placing and positioning the 'A3' size drawing sheet over the drawing table. Principal planes and projection, Division of line and circle in to equal parts, and construction of polygons

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UNIT 1: ENGINEERING CURVES, PROJECTION OF POINTS AND LINES

Construction of conic curves with their tangent and normal – ellipse, parabola, and hyperbola by eccentricity method

Construction of special curves with their tangent and normal – cycloid, epicycloid, and involute

Projection of points and I angle projection of lines inclined to both principal planes by rotating line method and trapezoidal rule – marking their traces.

Lab exercises: Study exercise – Introduction to Sketching (or) Drawing, and modification tools in CAD software (AutoCAD, CREO, CATIA, Solid Works, Inventor, Fusion 360)

(6+12 = 18 Hours)

Activities based learning: Identification of the curves used in the application given in the flash card, demonstration of the instantaneous centre of rotation of governors with respect to angle of inclination of the arms of the governors

UNIT 2: PROJECTION OF SURFACES & SOLIDS, AND 2D MODELING

Projection of surfaces inclined to both the principal planes – polygonal, trapezoidal, rhomboidal and circular

Projection of solids – prisms, pyramids, and axisymmetric solids when the axis inclined to both the principal planes – freely hanging – contour resting condition on either of the planes by rotating object method

Lab exercises: Construction of basic sketches – lines, circle, polygon, spline curves, coils, along with dimensioning. Familiarizing with geometric constraints and their types

(6+12 = 18 Hours)

Activities based learning: Making the solids using cardboards, shadow mapping and contour drawing at different orientation of the solids using torches

UNIT 3: 3D PROJECTION OF SOLIDS AND 3D MODELING OF SIMPLE PARTS

Free hand sketching – I & III angle projections of engineering parts and components

Isometric projection of combination of solids – prisms, pyramids, axisymmetric solids, frustum

Perspective projection of prisms, pyramids and axisymmetric solids by visual ray method

Lab exercises: 3D Modeling and 2D drafting of machine parts

(6+12 = 18 Hours)

Activities based learning: Flipped classroom for Free hand sketching, Jig saw activity for Isometric projection, arts and crafts for perspective view

UNIT 4: SECTION OF SOLIDS AND SECTIONED DRAFTING OF ASSEMBLED COMPONENTS

Section of simple and hollow solids – prisms, pyramids and axisymmetric solids, solids with holes/ slots when the section plane perpendicular to one principal plane and inclined to other principal plane ('On the axis' and 'from the axis' conditions)

Application based – section of beams (I, T, L, and C), section of pipe bracket, wood joints, composite walls, shells, flange of a coupling and other similar applications

Lab exercises: Assembly of parts with respect to engineering constraints, and sectioned drafting of assembled components

(6+12 = 18 Hours)

Activities based learning: Making of mitered joint in wood, sectioning the beams in different angles of orientation and identifying the true shape

UNIT 5: LATERAL SURFACE DEVELOPMENT AND SHEET METAL DESIGN

Lateral surface development of sectioned solids when the section plane perpendicular to VP and inclined to HP.

Application based – construction of funnel, chimney, dish antenna, door latch, trays, AC vents, lamp shade, commercial packaging boxes with respect to sectioning conditions and other similar applications

Lab exercises: Sheet metal design and drafting, drafting of coils, springs and screw threads

(6+12 = 18 Hours)

Activities based learning: Fabrication of funnels, chimney, lamp shade, boxes using card boards, ply woods, acrylics

Total: 90 Hours

Note: Activities based learning should not be covered in the regular class hours. It should be given as assignments to the group of maximum 3 members

COURSE OBJECTIVES

After successful completion of this course, the students will be able to:

1. Understand and use the engineering curves in engineering applications and projection techniques to construct conic curves, points and lines.
2. Develop skills in projecting surfaces and solids and create 2D models using CAD software.
3. Develop skills in 3D projection and 3D modeling of simple parts manually as well as using CAD software.
4. Understand and apply sectioning techniques to solids and assemble components.

5. Develop skills in lateral surface development and sheet metal design.

COURSE OUTCOMES

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

CO1: Construct and identify different types of conic curves and special curves, and project the points and lines pertaining to engineering applications

CO2: Project and visualize surfaces and solids in different orientations and utilize the CAD tools for designing.

CO3: Create and draft accurate 3D models and 2D drawings of machine parts manually as well as using CAD software

CO4: Determine the true shape of a sectioned solid and draft the assembled parts accordingly

CO5: Develop lateral surfaces of sectioned solids and design sheet metal components

Text book

1. “Engineering Drawing” by N S Parthasarathy and Vela Murali, Oxford University Press; UK ed. Edition, 2015.
2. “Engineering Drawing + Auto CAD” by Venugopal K, V. Prabhu Raja, New Age International Publishers, Sixth edition (1 January 2022).

References

1. "Basic Engineering Drawing: Mechanical Semester Pattern" by Mehta and Gupta, Charotar Publishing House, 2nd edition, 2018.
2. "Engineering Drawing" by Basant Agrawal and C M Agrawal, Vikas Publishing House, 3rd edition, 2020.
3. "Engineering Drawing With Auto CAD" by B V R Gupta, McGraw Hill Education, 4th edition, 2019.
4. "Engineering Drawing" by P S Gill, Tata McGraw Hill Education, 5th edition, 2018.
5. "Engineering Drawing with an Introduction to AutoCAD" by Dhananjay Jolhe, Cengage Learning, 2nd edition, 2020.
6. "Engineering Drawing" by M B Shah, Charotar Publishing House, 3rd edition, 2019
7. "Fundamentals of Engineering Drawing" by Imtiaz Hashmi, Pearson Education, 2nd edition, 2018.
8. "Computer Aided Engineering Drawing" by S Trymbaka Murthy, Scitech Publications, 3rd edition, 2020.
9. "CAED: Computer Aided Engineering Drawing for I/II Semester BE/Btech Courses" by Reddy K B, CBS Publishers & Distributors, 2nd, 2019.
10. "Computer-Aided Engineering Drawing" by Subrata Pal, Oxford University Press, 2nd, 2020.

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	3	2		1				3	1		3	3	3	2
2	3	3	2		2				3	2		3	3	3	2
3	3	3	3	1	2				3	3		3	3	3	2
4	3	3	3	1	3				3	3		3	3	3	2
5	3	3	3	1	3				3	3		3	3	3	2

ME23C05	BASICS OF MECHANICAL ENGINEERING	L	T	P	C
		2	0	0	2

UNIT I CASTING, FORMING, AND WELDING PROCESSES 6

Sand casting, lathe machine and its parts, lathe machine operations (turning, taper turning, facing, chamfering, etc.), Drilling, forming process – Bulk Deformation (Forging, Rolling), Sheet metal operation (Blanking, punching) – Demonstration of relevant experiments

UNIT II WELDING AND ADDITIVE MANUFACTURING 6

Welding – types, Shielded Metal Arc Welding, gas welding, MIG and TIG welding, Additive manufacturing : Types and its applications - Demonstration of relevant experiments

UNIT III THERMODYNAMICS 6

Basic Terminologies related to Thermodynamics, zeroth Law, First Law of thermodynamics, Second Law of thermodynamics, Third Law of thermodynamics, Vapor compression cycle , Air Conditioner and Refrigerator-Demonstration of relevant experiments

UNIT IV IC ENGINES AND RECENT DEVELOPMENTS 6

Introduction to IC Engine, 2 stroke Engine, 4 Stroke Engine, Petrol Engine, Diesel Engine –Demonstration Electric Vehicles - Introduction & Challenges –Demonstration of relevant experiments.

UNIT V POWER PLANT ENGINEERING 6

Coal based power plants- working, advantages & disadvantages, Hydro Electric power plants- working, advantages & disadvantages, nuclear power plants- Types, working, advantages & disadvantages, solar power plant- working, advantages & disadvantages, wind-based power generation- working, advantages & disadvantages.

TOTAL: 30 PERIODS

COURSE OUTCOMES:

Upon completion of the course, the students will be able to

- **CO1** Discuss the basic concepts of casting, forming, and machining processes
- **CO2** Explain welding, and Additive manufacturing
- **CO3** Discuss the basics laws and application of thermodynamics
- **CO4** Summarize the basics of IC engines, electric vehicles.
- **CO5** Explain various power generation methods

TEXT BOOKS:

1. Nag, P.K., “Engineering Thermodynamics “, IInd Edition, Tata McGraw Hill Publishing Co., Ltd., 1995.
2. Rajput, R .K, “Thermal Engineering”, Laxmi publications (P) Ltd, 2001.
3. Khurmi R.S., and Gupta J.K, “Theory of Machines”, Eurasia Publishing House (P) Ltd., 2004.
4. A TEXTBOOK OF MANUFACTURING TECHNOLOGY by RK Rajput, December 2007, Panchu Publisher
5. A Text-Book of Production Technology Volume I by O.P.KHANNA, Dhanpat Rai publications

REFERENCES:

1. Additive Manufacturing Technologies, Ian Gibson, David Rosen, Brent Stucker, Springer New York, NY, https://doi.org/10.1007/978-1-4939-2113-3.

2. Electric Vehicles, Modern Technologies and Trends, Nil Patel, Akash Kumar Bhoi, Sanjeevikumar Padmanaban, Jens Bo Holm-Nielsen, Spring3er Singapore, https://doi.org/10.1007/978-981-15-9251-5

Mapping COs and POs:																
COs	**POs**												**PSOs**			
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	-	-	-	2	-	2	-	-	-	-	2	3	-	1	-
CO2	3	-	-	-	2	-	2	-	-	-	-	2	3	-	1	-
CO3	3	-	-	-	2	-	2	-	-	-	-	2	3	-	1	-
CO4	3	-	-	-	2	-	2	-	-	-	-	2	3	-	1	-
CO5	3	-	-	-	2	-	2	-	-	-	-	2	3	-	1	-
Avg	3	-	-	-	2	-	2	-	-	-	-	2	3	-	1	-

CE23C03 **BASIC CIVIL ENGINEERING** **L T P C**
2 0 0 2

UNIT I CIVIL ENGINEERING MATERIALS 6
Traditional materials - Stone, timber, brick, lime, cement - Mortars - Concrete - Metals - Bitumen - Paints - Tiles.

UNIT II BUILDING CONSTRUCTION 6
Building elements - Planning - Types of buildings - Super structure - Substructure - Damp proofing.

UNIT III SURVEYING 6
Principles of surveying - Classification of surveying - Chain surveying - Compass surveying - Levelling - Theodolite - Total station - GIS - Remote sensing.

UNIT IV WATER SUPPLY AND SANITATION 6
Water supply engineering: Sources of water - Quality of water - Treatment.
Sanitary Engineering: Sewage - Sewage disposal - Septic tank - Treatment - Solid waste management.

UNIT V DISASTER MANAGEMENT 6
Types of disaster - Earthquake - Wind - Cyclone - Flood - Fire - Precautions to be taken - Disaster management and planning.

TOTAL: 30 PERIODS

COURSE OUTCOMES:

On completion of this course, the student is expected to be able to:

CO1	Identify the civil engineering materials for construction
CO2	Gain knowledge on construction of buildings
CO3	Acquire basic knowledge on various types of surveying
CO4	Get familiarized with the importance of water supply and sanitary engineering
CO5	Gain awareness on various natural disasters and their mitigation

TEXTBOOKS:

1. Bhavikatti S. S., “Basic Civil Engineering”, New Age International Publishers, New Delhi, 2010.
2. Punmia B. C., Ashok K. Jain, Arun K. Jain, “Basic Civil Engineering”, Laxmi Publications (P) Ltd., New Delhi, 2004.

REFERENCES:

1. Varghese P. C., “Building Materials”, Prentice Hall of India Learning Pvt. Ltd., New Delhi, 2015.
2. Arora S. P. and Bindra S. P., “The Textbook of Building Construction”, Dhanpat Rai Publishing Co. Pvt. Ltd., 2019.
3. Kanetkar T. P. and Kulkarni S. V., “Surveying and Levelling”, Pune Vidyarthi Griha Prakashan Publications, Pune, 2015.
4. Santosh Kumar Garg, “Environmental Engineering Volumes I and II”, Khanna Publishers, New Delhi, 2010.
5. Subramanian R., “Disaster Management", Vikas Publishing House, New Delhi, 2018.

CO-PO-PSO MAPPING: BASIC CIVIL ENGINEERING

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	2	3	2	3	3	3	3	2	2	3	3	3	3	3
2	3	2	3	2	3	3	3	3	3	3	2	3	3	3	3
3	3	3	3	3	3	2	2	3	2	2	3	3	3	3	3
4	2	2	2	2	3	2	1	1	1	1	1	1	3	3	3
5	2	2	3	2	2	3	3	2	3	2	2	3	3	3	3
Avg.	**3**	**2**	**3**	**2**	**3**	**3**	**2**	**2**	**2**	**2**	**2**	**3**	**3**	**3**	**3**

CS23304 **PROGRAMMING IN C** **L T P C**
2 0 4 4

UNIT I BASICS OF C PROGRAMMING 6+12

Introduction to programming paradigms –- Structure of C program - C programming: Data Types - Constants - Keywords - Operators: Precedence and Associativity - Expressions - Input/Output statements, Assignment statements - Decision making statements - Switch statement.

PRACTICALS

1. Designing programs with algorithms/flowchart
2. Programs for i/o operations with different data types

UNIT II LOOP CONTROL STATEMENTS AND ARRAYS 6+12

Iteration statements: For, while, Do-while statements, nested loops, break & continue statements - Introduction to Arrays: Declaration, Initialization - One dimensional array -Two dimensional arrays – Searching and sorting in Arrays – Strings – string handling functions - array of strings

PRACTICALS

1. Programs using various operators
2. Programs using decision making and branching statements
3. Programs using for, while, do-while loops and nested loops.
4. Programs using arrays and operations on arrays.
5. Programs implementing searching and sorting using arrays
6. Programs implementing string operations on arrays

UNIT III FUNCTIONS AND POINTERS 6+12

Modular programming - Function prototype, function definition, function call, Built-in functions – Recursion – Recursive functions - Pointers - Pointer increment, Pointer arithmetic - Parameter passing: Pass by value, Pass by reference, pointer and arrays, dynamic memory allocation

PRACTICALS

1. Programs using functions
2. Programs using recursion
3. Programs using pointers & strings with pointers
4. Programs using Dynamic Memory Allocation

UNIT IV STRUCTURES AND UNION 6+12

Storage classes, Structure and union, Features of structures, Declaration and initialization of structures, array of structures, Pointer to structure, structure and functions, typedef , bit fields , enumerated data types, Union.

PRACTICALS

1. Programs using Structures
2. Programs using Unions
3. Programs using pointers to structures and self-referential structures.

UNIT V MACROS AND FILE PROCESSING 6+12

Preprocessor directives – Simple and Conditional macros with and without parameters - Files - Types of file processing: Sequential and Random access – File operations – read, write & seek.

PRACTICALS

1. Programs using pre-processor directives & macros
2. Programs to handle file operations
3. Programs to handle file with structure

TOTAL: 90 (30+60) PERIODS

TEXT BOOKS:

1. Kernighan, B.W and Ritchie,D.M, "The C Programming language", Second Edition, Pearson Education, 2015.
2. Yashwant Kanetkar, Let us C, 17th Edition, BPB Publications, 2020.

REFERENCES:

1. Pradip Dey, Manas Ghosh, "Computer Fundamentals and Programming in C", Second Edition, Oxford University Press, 2013.
2. Ashok N Kamthane, Programming in C, Pearson, Third Edition, 2020
3. Reema Thareja, "Programming in C", Oxford University Press, Second Edition, 2016.
4. Paul Deitel and Harvey Deitel, "C How to Program with an Introduction to C++", Eighth edition, Pearson Education, 2018.
5. Byron S. Gottfried, "Schaum's Outline of Theory and Problems of Programming with C"' McGraw-Hill Education, 1996.
6. Anita Goel and Ajay Mittal, "Computer Fundamentals and Programming in C", 1st Edition, Pearson Education, 2013.

COURSE OUTCOMES:

Upon completion of the course, the students will be able to

CO1: Write simple C programs using basic constructs.
CO2: Design searching and sorting algorithms using arrays and strings.
CO3: Implement modular applications using Functions and pointers.
CO4: Develop and execute applications using structures and Unions.
CO5: Illustrate algorithmic solutions in C programming language using files.

Total Hours: 90 (30+60)

CO-PO MAPPING

CO	PO1	PO 2	PO 3	PO4	PO 5	PO 6	PO 7	PO 8	PO9	PO10	PO1 1	PO12	PSO 1	PSO 2	PSO 3
1	2	3	1	3	2	1	-	-	-	2	-	3	1	2	2
2	2	1	1	3	2	1	-	-	-	-	-	3	1	2	2
3	2	2	1	3	2	1	-	-	3	-	3	3	1	2	2
4	2	1	1	3	2	1	-	-	3	-	3	3	1	2	2
5	2	3	1	3	2	1	-	-	-	2	3	3	1	2	2

1 - low, 2 - medium, 3 – high

UC23H01 **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 சமயச் சார்பற்ற தன்மை – சங்க இலக்கியத்தில் பகிர்தல் அறம் – திருக்குறளில் மேலாண்மைக் கருத்துக்கள் – தமிழ்க் 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 தமிழகத்தில் 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 C ivilization on the banks of river Vaigai' (Jointly Published by: Department ofArchaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)

10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Publishedby: The Author)

11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Bookand Educational Services Corporation, Tamil Nadu)

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

UC23H01 HERITAGE OF TAMILS L T P C
1 0 0 1

UNIT I LANGUAGE AND LITERATURE 3

Language Families in India - Dravidian Languages – Tamil as aClassical Language - Classical Literature in Tamil – Secular Nature of Sangam Literature – Distributive Justice in Sangam Literature - Management Principles in Thirukural - Tamil Epics and Impact of Buddhism & Jainism in Tamil Land - Bakthi Literature Azhwars and Nayanmars - Forms of minor Poetry - Development of Modern literature in Tamil - Contribution of Bharathiyar and Bharathidhasan.

UNIT II HERITAGE - ROCK ART PAINTINGS TO MODERN ART – SCULPTURE 3

Hero stone to modern sculpture - Bronze icons - Tribes and their handicrafts - Art of temple car making - - Massive Terracotta sculptures, Village deities, Thiruvalluvar Statue at Kanyakumari, Making of musical instruments - Mridhangam, Parai, Veenai, Yazh and Nadhaswaram - Role of Temples in Social and Economic Life of Tamils.

UNIT III FOLK AND MARTIAL ARTS 3

Therukoothu, Karagattam, Villu Pattu, Kaniyan Koothu, Oyillattam, Leatherpuppetry, Silambattam, Valari, Tiger dance - Sports and Games of Tamils.

UNIT IV THINAI CONCEPT OF TAMILS 3

Flora and Fauna of Tamils & Aham and Puram Concept from Tholkappiyam and Sangam Literature - Aram Concept of Tamils - Education and Literacy during Sangam Age - Ancient Cities and Ports of Sangam Age - Export and Import during Sangam Age - Overseas Conquest of Cholas.

UNIT V CONTRIBUTION OF TAMILS TO INDIAN NATIONAL MOVEMENT AND INDIAN CULTURE 3

Contribution of Tamils to Indian Freedom Struggle - The Cultural Influence of Tamils over the other parts of India – Self-Respect Movement - Role of Siddha Medicine in Indigenous Systems of Medicine – Inscriptions & Manuscripts – Print History of Tamil Books.

TOTAL : 15 PERIODS

TEXT-CUM-REFERENCE BOOKS

1. 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 C ivilization on the banks of river Vaigai' (Jointly Published by: Department ofArchaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)

10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Publishedby: The Author)

11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Bookand Educational Services Corporation, Tamil Nadu)

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

NCC Credit Course Level 1*

UC23P01	(ARMY WING) NCC Credit Course Level - I	L T P C 2 0 0 2

NCC GENERAL **6**

NCC 1	Aims, Objectives & Organization of NCC	1
NCC 2	Incentives	2
NCC 3	Duties of NCC Cadet	1
NCC 4	NCC Camps: Types & Conduct	2

NATIONAL INTEGRATION AND AWARENESS **4**

NI 1	National Integration: Importance & Necessity	1
NI 2	Factors Affecting National Integration	1
NI 3	Unity in Diversity & Role of NCC in Nation Building	1
NI 4	Threats to National Security	1

PERSONALITY DEVELOPMENT **7**

PD 1	Self-Awareness, Empathy, Critical & Creative Thinking, Decision Making and Problem Solving	2
PD 2	Communication Skills	3
PD 3	Group Discussion: Stress & Emotions	2

LEADERSHIP **5**

L 1	Leadership Capsule: Traits, Indicators, Motivation, Moral Values, Honour ‘Code	3
L 2	Case Studies: Shivaji, Jhasi Ki Rani	2

SOCIAL SERVICE AND COMMUNITY DEVELOPMENT **8**

SS 1	Basics, Rural Development Programmes, NGOs, Contribution of Youth	3
SS 4	Protection of Children and Women Safety	1
SS 5	Road / Rail Travel Safety	1
SS 6	New Initiatives	2
SS 7	Cyber and Mobile Security Awareness	1

TOTAL : 30 PERIODS

NCC Credit Course Level 1*

UC23P02	**(NAVAL WING) NCC Credit Course Level – I**	**L T P C** **2 0 0 2**
NCC GENERAL		**6**
NCC 1	Aims, Objectives & Organization of NCC	1
NCC 2	Incentives	2
NCC 3	Duties of NCC Cadet	1
NCC 4	NCC Camps: Types & Conduct	2
NATIONAL INTEGRATION AND AWARENESS		**4**
NI 1	National Integration: Importance & Necessity	1
NI 2	Factors Affecting National Integration	1
NI 3	Unity in Diversity & Role of NCC in Nation Building	1
NI 4	Threats to National Security	1
PERSONALITY DEVELOPMENT		**7**
PD 1	Self-Awareness, Empathy, Critical & Creative Thinking, Decision Making and Problem Solving	2
PD 2	Communication Skills	3
PD 3	Group Discussion: Stress & Emotions	2
LEADERSHIP		**5**
L 1	Leadership Capsule: Traits, Indicators, Motivation, Moral Values, Honour Code	3
L 2	Case Studies: Shivaji, Jhasi Ki Rani	2
SOCIAL SERVICE AND COMMUNITY DEVELOPMENT		**8**
SS 1	Basics, Rural Development Programmes, NGOs, Contribution of Youth	3
SS 4	Protection of Children and Women Safety	1
SS 5	Road / Rail Travel Safety	1
SS 6	New Initiatives	2
SS 7	Cyber and Mobile Security Awareness	1

TOTAL : 30 PERIODS

NCC Credit Course Level 1*

UC23P03	**(AIR FORCE WING) NCC Credit Course Level – I**	**L T P C** **2 0 0 2**
NCC GENERAL		**6**
NCC 1	Aims, Objectives & Organization of NCC	1
NCC 2	Incentives	2
NCC 3	Duties of NCC Cadet	1
NCC 4	NCC Camps: Types & Conduct	2
NATIONAL INTEGRATION AND AWARENESS		**4**
NI 1	National Integration: Importance & Necessity	1
NI 2	Factors Affecting National Integration	1
NI 3	Unity in Diversity & Role of NCC in Nation Building	1
NI 4	Threats to National Security	1
PERSONALITY DEVELOPMENT		**7**
PD 1	Self-Awareness, Empathy, Critical & Creative Thinking, Decision Making and Problem Solving	2
PD 2	Communication Skills	3
PD 3	Group Discussion: Stress & Emotions	2
LEADERSHIP		**5**
L 1	Leadership Capsule: Traits, Indicators, Motivation, Moral Values, Honour Code	3
L 2	Case Studies: Shivaji, Jhasi Ki Rani	2
SOCIAL SERVICE AND COMMUNITY DEVELOPMENT		**8**
SS 1	Basics, Rural Development Programmes, NGOs, Contribution of Youth	3
SS 4	Protection of Children and Women Safety	1
SS 5	Road / Rail Travel Safety	1
SS 6	New Initiatives	2
SS 7	Cyber and Mobile Security Awareness	1

TOTAL : 30 PERIODS

EN23C02	PROFESSIONAL COMMUNICATION	L T P C 2 0 2 3

COURSE OBJECTIVES:

- To read and comprehend different forms of official texts.
- To develop students' writing skills in professional context.
- To actively listen, read and understand written and oral communication in a professional context.
- To comprehend and analyse the visual content in authentic context.
- To write professional documents with clarity and precision

UNIT I CAUSE AND EFFECT 6

Reading – Newspaper articles on Social and Environmental issues; Writing – Instructions, Cause and effect essay; Grammar - Modal verbs; Vocabulary – Cause and effect, Idioms

LAB ACTIVITY: 6

Listening and Speaking – Listen to news reports and summarise in oral form.

UNIT II CLASSIFICATION 6

Reading – An article, social media posts and classifying based on the content; Writing – Definition, Note making, Note taking (Cornell notes etc.) and Summarising; Grammar – Connectives; Vocabulary – Phrasal verbs

LAB ACTIVITY: 6

Listening and speaking: Social interaction (Conversation including small talk)

UNIT III PROBLEM AND SOLUTION 6

Reading – Visual content (Tables/charts/graphs) for comprehension; Writing - Problem and Solution Essay; Grammar – If conditionals; Vocabulary – Sequential words.

LAB ACTIVITY: 6

Listening – Group discussion; Speaking – Participating in a group discussion

UNIT IV REPORT 6

Reading – Formal report on accidents (industrial/engineering); Writing – Industrial Accident report; Grammar – Active and passive voice, Direct and Indirect speech; Vocabulary – Numerical adjectives.

LAB ACTIVITY: 6

Listening / watching – Television documentary and discussing its content, purpose etc.

UNIT V JOB APPLICATION AND INTERVIEW 6

Reading - Job advertisement and company profile; Writing – Job application (cover letter and CV) Grammar – Mixed Tenses; Vocabulary – Collocations related to work environment

LAB ACTIVITY: 6

Listening – Job interview; Speaking – Mock interviews

TOTAL: 60 PERIODS

TEACHING METHODOLOGY

Interactive lectures, role plays, group discussions, listening and speaking labs, technology enabled language teaching, flipped classroom.

EVALUATION PATTERN

Internal Assessment
- Written assessments
- Assignment

Lab Assessment
- Group discussion (Peer assessment)
- Listening

External Assessment
End Semester Examination

LEARNING OUTCOMES

By the end of the courses, students will be able to
- To apply appropriate language structure and vocabulary to enhance both spoken and written communication in formal contexts.
- Comprehend different forms of official documents
- Write professional documents coherently and cohesively.
- Interpret verbal and graphic content in authentic context
- Analyse and evaluate verbal and audio visual materials.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										√		√
CO2										√		√
CO3										√		√
CO4										√		√
CO5										√		√

TEXT BOOKS:

1. “English for Engineers and Technologists” Volume 2 by Orient Blackswan, 2022
2. “English for Science & Technology - II” by Cambridge University Press, 2023.

REFERENCES:

1. “Communicative English for Engifneers and Professionals” by Bhatnagar Nitin, Pearson India, 2010.
2. ”Take Off – Technical English for Engineering” by David Morgan, Garnet Education, 2008.
3. “Advanced Communication Skills” by Mathew Richardson, Charlie Creative Lab, 2020.
4. www.uefap.com

MA23C02	ORDINARY DIFFERENTIAL EQUATIONS AND TRANSFORM TECHNIQUES	L	T	P	C
		3	1	0	4

OBJECTIVES:

- To acquaint the students with Differential Equations which are significantly used in engineering problems.
- To make the students to understand the Laplace transforms techniques.
- To develop the analytic solutions for partial differential equations used in engineering by Fourier series.
- To acquaint the student with Fourier transform techniques used in wide variety of situations in which the functions used are not periodic.
- To develop Z- transform techniques in solving difference equations.

UNIT I ORDINARY DIFFERENTIAL EQUATIONS 9+3

Homogeneous linear ordinary differential equations of second order -superposition principle - general solution- Particular integral - Operator method - Solution by variation of parameters - Method of undetermined coefficients - Homogeneous equations of Euler–Cauchy and Legendre's type – System of simultaneous linear differential equations with constant coefficients.

UNIT II LAPLACE TRANSFORMS 9+3

Existence theorem - Transform of standard functions – Transform of Unit step function and Dirac delta function – Basic properties - Shifting theorems - Transforms of derivatives and integrals – Transform of periodic functions - Initial and Final value theorem - Inverse Laplace transforms- Convolution theorem (without proof) – Solving Initial value problems by using Laplace Transform techniques.

UNIT III FOURIER SERIES 9+3

Dirichlet's conditions – General Fourier series – Odd and even functions – Half-range Sine and Cosine series – Complex form of Fourier series – Parseval's identity – Computation of harmonics.

UNIT IV FOURIER TRANSFORMS 9+3

Fourier integral theorem – Fourier transform pair - Fourier sine and cosine transforms – Properties – Transform of elementary functions – Inverse Fourier Transforms - Convolution theorem (without proof) – Parsevals's identity.

UNIT V Z – TRANSFORM AND DIFFERENCE EQUATIONS 9+3

Z-transform – Properties of Z-transform – Inverse Z-transform – Convolution theorem – Evaluation of Inverse Z transform using partial fraction method and convolution theorem - Initial and final value theorems – Formation of difference equations – Solution of difference equations using Z - transform.

TOTAL: 60 PERIODS

Laboratory based exercises / assignments / assessments will be given to students from the content of the course wherever applicable.

Branch specific / General Engineering applications based on the content of each units will be introduced to students wherever possible.

Suggested Laboratory based exercises / assignments / assessments :

Ordinary differential equations

1. Symbolic computation of linear ordinary differential equations
2. Solving System of simultaneous linear differential equations using ODE SOLVER

Laplace transforms

1. Symbolic computation of Laplace transform and Inverse Laplace transform
2. Plotting Laplace transforms

Fourier Series

1. Symbolic computation of Fourier Coefficients
2. Computation of harmonics
3. Plotting truncated Fourier Series

Fourier Transform

1. Symbolic computation of Fourier Transforms
2. Plotting truncated Fourier Transforms

Z – transform

1. Symbolic computation of Z-Transforms

OUTCOMES:

CO1 :Solve higher order ordinary differential equations which arise in engineering applications.
CO2 :Apply Laplace transform techniques in solving linear differential equations.
CO3 :Apply Fourier series techniques in engineering applications.
CO4 :Understand the Fourier transforms techniques in solving engineering problems.
CO5 :Understand the Z-transforms techniques in solving difference equations.

TEXT BOOKS:

1. Grewal B.S., “Higher Engineering Mathematics”, Khanna Publishers, 45th Edition, New Delhi, 2020.
2. Erwin Kreyszig, "Advanced Engineering Mathematics", 10th Edition, Wiley India Pvt Ltd., New Delhi, 2018.

REFERENCES:

1. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2008
2. Greenberg M.D., “Advanced Engineering Mathematics”, Pearson Education2nd Edition, 5th Reprint, Delhi, 2009.
3. Jain R.K. and Iyengar S.R.K., “Advanced Engineering Mathematics”,Narosa Publications, 5 th Edition, New Delhi, 2017.
4. Peter V.O’Neil, “Advanced Engineering Mathematics”, Cengage Learning India Pvt., Ltd, 7 th Edition, New Delhi , 2012.
5. Ramana B.V., “Higher Engineering Mathematics”, Tata McGraw Hill Co. Ltd., 11th Reprint, New Delhi, 2010.

CO – PO Mapping:

Course Outcomes	PROGRAMME OUTCOMES											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	P12
CO 1 :	3	3	2	3	1	2	1	1	1	1	1	3
CO 2 :	3	3	2	3	1	2	1	1	1	1	1	3
CO 3 :	3	3	2	3	1	2	1	1	1	1	1	3
CO 4 :	3	3	2	3	1	2	1	1	1	1	1	3
CO 5 :	3	3	2	3	1	2	1	1	1	1	1	3

CY23C01 **ENGINEERING CHEMISTRY** **L T P C**
3 0 2 4

UNIT I WATER TECHNOLOGY

Water – sources and impurities – water quality parameters: colour, odour, pH, hardness, alkalinity, TDS, COD, BOD, and heavy metals. Boiler feed water – requirement – troubles (scale & sludge, caustic embrittlement, boiler corrosion and priming & foaming. Internal conditioning – phosphate, Calgon, and carbonate treatment. External conditioning – demineralization. Municipal water treatment (screening, sedimentation, coagulation, filtration, disinfection-ozonolysis, UV treatment, chlorination), Reverse Osmosis – desalination.

PRACTICAL:

- Estimation of HCl using Na_2CO_3 as the primary standard
- Determination of alkalinity in the water sample.
- Determination of hardness of water by EDTA method.
- Determination of DO content of water sample by Winkler's method.

UNIT II NANOCHEMISTRY

Basics-distinction between molecules, nanomaterials and bulk materials; size-dependent properties (optical, electrical, mechanical, magnetic and catalytic). Types –nanoparticle, nanocluster, nanorod, nanowire and nanotube. Preparation of nanomaterials: sol-gel, solvothermal, laser ablation, chemical vapour deposition, electrochemical deposition and electro-spinning. Characterization - Scanning Electron Microscope and Transmission Electron Microscope - Principle and instrumentation (block diagram). Applications of nanomaterials – medicine including AYUSH, automobiles, electronics, and cosmetics.

PRACTICAL:

- Preparation of nanoparticles by Sol-Gel method/sonication method.
- Preparation of nanowire by Electrospinning.
- Study of morphology of nanomaterials by scanning electron microscopy

UNIT III CORROSION SCIENCE

Introduction to corrosion – chemical and electrochemical corrosions – mechanism of electrochemical and galvanic corrosions – concentration cell corrosion-soil, pitting, inter-granular, water line, stress and microbiological corrosions-galvanic series-factors influencing corrosion- measurement of corrosion rate. Electrochemical protection – sacrificial anodic protection and impressed current cathodic protection. Protective coatings-metallic coatings (galvanizing, tinning), organic coatings (paints). Paints: Constituents and functions.

PRACTICAL:

- Corrosion experiment-weight loss method.
- Salt spray test for corrosion study.
- Corrosion prevention by electroplating.
- Estimation of corroded Iron by Potentiometry/UV-visible spectrophotometer

UNIT IV ENERGY SOURCES

Electrochemical cell, redox reaction, electrode potential – oxidation and reduction potential. Batteries – Characteristics; types of batteries; primary battery (dry cell), secondary battery (lead acid, lithium-ion battery) and their applications. Emerging energy sources – metal hydride battery, hydrogen energy, Fuel cells – H_2-O_2 fuel cell. Supercapacitors –Types and Applications, Renewable Energy: solar heating and solar cells. Recycling and disposal of batteries.

PRACTICAL:

- Study of components of Lead acid battery.
- Measurement of voltage in a photovoltaic cell.
- Working of $H_2 – O_2$ fuel cell

UNIT V POLYMER CHEMISTRY

Introduction: Functionality-degree of polymerization. Classification of polymers (Source, Structure, Synthesis and Intermolecular forces). Mechanism of free radical addition polymerization. Properties of polymers: Tg, tacticity, molecular weight-number average, weight average, viscosity average and polydispersity index (Problems). Techniques of polymerization: Bulk, emulsion, solution and suspension. Compounding and Fabrication Techniques: Injection, Extrusion, Blow and Calendaring. Polyamides, Polycarbonates and Polyurethanes – structure and applications. Recycling of polymers.

PRACTICAL:

- Determination of molecular weight of a polymer using Ostwald viscometer.
- Preparation of a polymer.
- Determination of molecular weight by Gel Permeation Chromatography.

TOTAL: 75 PERIODS

COURSE OUTCOMES:

CO1: To demonstrate knowledge of water quality in various industries and develop skills in analyzing water quality parameters for both domestic and industrial purposes.

CO2: To identify and apply fundamental concepts of nanoscience and nanotechnology for engineering and technology applications, and to develop skills in synthesizing nanomaterials and studying their morphology.

CO3: To apply fundamental knowledge of corrosion protection techniques and develop skills to conduct experiments for measuring and preventing corrosion.

CO4: To study the fundamentals of energy storage devices and develop skills in constructing and experimenting with batteries.

CO5: To recognize and apply basic knowledge of different types of polymeric materials and develop skills in preparing and determining their applications for futuristic material fabrication needs.

TEXT BOOKS:

1. Jain P. C. & Monica Jain., “Engineering Chemistry”, 17th Edition, Dhanpat Rai Publishing Company (P) Ltd, New Delhi, 2015.
2. Sivasankar B., “Engineering Chemistry”, Tata McGraw-Hill Publishing Company Ltd, New Delhi, 2012.
3. Dara S.S., “A Textbook of Engineering Chemistry”, Chand Publications, 2004.
4. Laboratory Manual - Department of Chemistry, CEGC, Anna University (2023).

REFERENCES:

1. Schdeva M.V., “Basics of Nano Chemistry”, Anmol Publications Pvt Ltd, 2011.
2. Friedrich Emich, “Engineering Chemistry”, Medtech, 2014.
3. Gowariker V.R., Viswanathan N.V. and Jayadev Sreedhar, “Polymer Science” New AGE International Publishers, 2009.
4. Vogel’s Textbook of Quantitative Chemical Analysis (8th edition, 2014).

CO - PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	-	-	-	-	3	-	-	-	-	-
CO2	3	-	2	-	2	-	3	-	-	-	-	-
CO3	3	3	2	-	2	-	3	-	-	-	-	-
CO4	3	3	-	-	-	-	3	-	-	-	-	-
CO5	3	-	-	-	-	-	3	-	-	-	-	-
Avg	3	3	-	-	-	-	3	-	-	-	-	-

1’ = Low; ‘2’ = Medium; ‘3’ = High

PH23C10 **ELECTRONIC PROPERTIES OF MATERIALS** **L T P C**
(**Common to EEE and EI Branches**) **3 0 0 3**

OBJECTIVES:

- To understand the electrical properties of materials and the classification of solids.
- To instill knowledge on the physics of semiconductors, and device applications
- To install knowledge on the physics of dielectric and magnetic materials and device applications
- To establish a sound knowledge on different optical properties of materials, optical displays and applications
- To in calculate an idea of the significance of nanostructures, quantum confinement and ensuing nanodevice applications.

UNIT I ELECTRICAL PROPERTIES OF MATERIALS 9

Classical free electron theory - Expression for electrical conductivity–Thermal conductivity, expression Wiedemann – Franz law - Quantum free electron theory - Degenerate energy states– Density of States - Fermi-Dirac statistics – Conduction electron density – Electron in a periodic potential – Energy bands in solids – Conductors – Semiconductors – Insulators – tight-binding approximation- Electron effective mass– the concept of hole.

UNIT II SEMICONDUCTORS AND TRANSPORT PHYSICS 9

Intrinsic Semiconductors – Energy band diagram – direct and indirect bandgap semiconductors– Carrier concentration in intrinsic semiconductors – Determination of band gap – extrinsic semiconductors - Carrier concentration in N-type & P-type semiconductors – Variation of carrier concentration with temperature – Carrier transport in Semiconductors: Drift, mobility, diffusion and carrier lifetime – Hall effect -devices and sensors – Ohmic contacts – Peltier coolers - Schottky diode – solar cell.

UNIT III DIELECTRIC AND MAGNETIC PROPERTIES OF MATERIALS 9

Electric Dipole moment and polarization vector, Polarization mechanisms: electronic, ionic, orientational, interfacial and total polarization - dielectric constant and dielectric loss - dielectric strength and insulation – Applications of dielectric materials. Origin of Magnetism - atomic magnetic moments – Bohr magneton-magnetic materials: diamagnetism, paramagnetism, ferromagnetism, antiferromagnetism, ferrimagnetism - Ferromagnetism – origin and exchange interaction - Domain theory -saturation magnetization and curie temperature-domain walls and motion – Hysteresis –- soft and hard magnetic materials – GMR effect - GMR materials – Applications – Magnetic data storage.

UNITI V OPTICAL PROPERTIES OF MATERIALS 9

Light waves in a homogeneous medium - refractive index - dispersion: refractive index-wavelength behavior - group velocity and group index - Fresnel's equations: reflection and transmission coefficients, Absorption, emission and scattering of light – Luminescence – Phosphors LED's : Principle and working – white LED, Laser diode – optical Amplifiers - Organic LED and Plasma light emitting devices, LCD - Homojunction and Hetero junction laser diodes. Optical data storage techniques(CD, DVD and Blue-ray disc,

UNIT V NANODEVICES 9

Electron density in a conductor – Significance between Fermi energy and volume of the material –Quantum confinement – Quantum structures – Density of states for quantum wells, wires and dots –Band gap of nanomaterials –Tunneling – Single electron phenomena – Single electron Transistor. The conductivity of metallic nanowires – Ballistic transport – Quantum resistance and conductance –Carbon nanotubes: Properties and applications Transporters – Spintronic devices and application.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

After completing the above subject, students will have

CO1: Knowledge of the electrical properties of materials

CO2: Acquire an adequate understanding of semiconductor physics and the functioning of semiconducto devices

CO3: Come to have firm knowledge of the dielectric and magnetic properties of materials and the applications

CO4: Understand the optical properties of materials and working principles of various optical devices

CO5: Appreciate the importance of nanotechnology, the physics of nanodevices, low-dimension structures and their applications

REFERENCES:

1. W.D.Callitser and D.G. Rethwish. Materials Science and Engineering. John Wiley & Sons, 2014.
2. S.O.Kasap. Principles of Electronic Materials and Devices. McGraw Hill Education, 2017.
3. R.F.Pierret. Semiconductor Device Fundamentals. Pearson, 2006.
4. N.Garcia, A. Damask and S.Schwarz. Physics for Computer Science Students. Springer-Verlag, 2012.
5. G.W. Hanson, Fundamentals of Nanoelectronics. Pearson Education, 2009.
6. J. Wilson and J.F.B. Hawkes. Optoelectronics. Pearson Education, 2018.
7. N. Gershenfeld. The Physics of Information Technology. Cambridge University Press, 2011.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	1	1	1							
CO2	2	2	1	1	1							
CO3	2	2	1	2	1							
CO4	2	2	2	1	1							
CO5	2	1	2	2	1							

ME23C04	MAKERSPACE	L	T	P	C
		1	0	4	3

COURSE OBJECTIVES:

1. To practice the usage of various tools towards assembly and dis-assembly of different items / equipment.
2. To make simple part / component using welding processes.
3. To train on the basic wiring practices of boards, machines, etc.
4. To provide a hands-on experience on the use of electronic components, equipment, sensors and actuators.
5. To expose to modern computer tools and advanced manufacturing / fabrication processes.

LIST OF ACTIVITIES **1L,4P**

(A). Dis-assembly & Assembly Practices

i. Tools and its handling techniques.

ii. Dis-assembly and assembly of home appliances – Grinder Mixer Grinder, Ceiling Fan, Table Fan & Washing Machine.

iii. Dis-assembly and assembly of Air-Conditioners & Refrigerators.

iv. Dis-assembly and assembly of a Bicycle.

(B). Welding Practices

i. Welding Procedure, Selection & Safety Measures.

ii. Power source of Arc Welding – Gas Metal Arc Welding & Gas Tungsten Arc Welding processes.

iii. Hands-on session of preparing base material & Joint groove for welding.

iv. Hands-on session of MAW, GMAW, GTAW, on Carbon Steel & Stainless Stell plates / pipes, for fabrication of a simple part.

(C). Electrical Wiring Practices

i. Electrical Installation tools, equipment & safety measures.

ii. Hands-on session of basic electrical connections for Fuses, Miniature Circuit Breakers and Distribution Box,

iii. Hands-on session of electrical connections for Lightings, Fans, Calling Bells.

iv. Hands-on session of electrical connections for Motors & Uninterruptible Power Supply.

(D). Electronics Components / Equipment Practices

i. Electronic components, equipment & safety measures.

ii. Dis-assembly and assembly of Computers.

iii. Hands-on session of Soldering Practices in a Printed Circuit Breaker.

iv. Hands-on session of Bridge Rectifier, Op-Amp and Transimpedance amplifier.

v. Hands-on session of integration of sensors and actuators with a Microcontroller.

vi. Demonstration of Programmable Logic Control Circuit.

(E).Contemporary Systems

i. Demonstration of Solid Modelling of components.

ii. Demonstration of Assembly Modelling of components.

iii. Fabrication of simple components / parts using 3D Printers.

iv. Demonstration of cutting of wood / metal in different complex shapes using Laser Cutting Machine.

TOTAL: 75 Periods (15 Lecture + 60 Practical)

COURSE OUTCOMES:

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

CO1: Assemble and dis-assemble various items / equipment.

CO2: Make simple parts using suitable welding processes.

CO3: Setup wiring of distribution boards, machines, etc.

CO4: Utilise the electronic components to fabricate a simple equipment, aided with sensors and actuators.

CO5: Take advantage of modern manufacturing practices.

REFERENCES:

1. Stephen Christena, Learn to Weld: Beginning MIG Welding and Metal Fabrication Basics, Crestline Books, 2014.
2. H. Lipson, Fabricated - The New World of 3D Printing, Wiley, 1st edition, 2013.
3. Code of Practice for Electrical Wiring Installations (IS 732:2019)
4. A.S. Sedra and K.C. Smith, Microelectronic Circuits, Oxford University Press, 7th ed. (Indian edition), 2017.
5. Mazidi, Naimi, Naimi, AVR Microcontroller and Embedded Systems: Using Assembly and C, Pearson India, 1st edition 2013.
6. Visualization, Modeling, and Graphics for Engineering Design, D.K. Lieu, S.A. Sorby, Cengage Learning; 2nd edition.

ME23C03	ENGINEERING MECHANICS	L T P C 3 1 0 4

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students for:

- Determining the resultant forces acting on a particle in 2D and 3D and for applying methods of equilibrium on a particle in 2D and 3D.
- Evaluating the reaction forces for bodies under equilibrium, for determining the moment of a force, moment of a couple, for resolving force into a force-couple system and for analyzing trusses
- Assessing the centroids of 2D sections / center of gravity of volumes and for calculating area moments of inertia for the sections and mass moment of inertia of solids.
- Evaluating the frictional forces acting at the contact surfaces of various engineering systems and for applying the work-energy principles on a particle.
- Determining kinetic and kinematic parameters of the rigid bodies subjected to concurrent coplanar forces.

UNIT I STATICS OF PARTICLES 9+3

Fundamental Concepts and Principles, Systems of Units, Method of Problem Solutions, Statics of Particles -Forces in a Plane, Resultant of Forces, Resolution of a Force into Components, Rectangular Components of a Force, Unit Vectors. Equilibrium of a Particle- Newton's First Law of Motion, Space and Free-Body Diagrams, Forces in Space, Equilibrium of a Particle in Space.

UNIT II EQUILIBRIUM OF RIGID BODIES AND TRUSSES 9+3

Principle of Transmissibility, Equivalent Forces, Vector Product of Two Vectors, Moment of a Force about a Point, Varignon's Theorem, Rectangular Components of the Moment of a Force, Scalar Product of Two Vectors, Mixed Triple Product of Three Vectors, Moment of a Force about an Axis, Couple - Moment of a Couple, Equivalent Couples, Addition of Couples, Resolution of a Given Force into a Force -Couple system, Further Reduction of a System of Forces, Equilibrium in Two and Three Dimensions - Reactions at Supports and Connections – Analysis of Trusses – Method of Joints and Method of Sections.

UNIT III DISTRIBUTED FORCES 9+3

Centroids of lines and areas – symmetrical and unsymmetrical shapes, Determination of Centroids by Integration, Theorems of Pappus-Guldinus, Distributed Loads on Beams, Centre of Gravity of a Three-Dimensional Body, Centroid of a Volume, Composite Bodies, Determination of Centroids of Volumes by Integration.

Moments of Inertia of Areas and Mass - Determination of the Moment of Inertia of an Area by Integration , Polar Moment of Inertia , Radius of Gyration of an Area , Parallel-Axis Theorem , Moments of Inertia of Composite Areas, Moments of Inertia of a Mass - Moments of Inertia of Thin Plates , Determination of the Moment of Inertia of a Three-Dimensional Body by Integration.

UNIT IV FRICTION AND WORK PRINCIPLES 9+3

The Laws of Dry Friction. Coefficients of Friction, Angles of Friction, Wedges, Wheel Friction. Rolling Resistance, Ladder friction. Work of a Force, Kinetic Energy of a Particle, Principle of Work and Energy, Principle of Impulse and Momentum, Impact, Method of Virtual Work - Work of a Force, Potential Energy, Potential Energy and Equilibrium.

UNIT V DYNAMICS OF PARTICLES AND RIGID BODIES 9+3

Kinematics - Rectilinear Motion and Curvilinear Motion of Particles. Kinetics- Newton's Second Law of Motion -Equations of Motions, Dynamic Equilibrium, Energy and Momentum Methods – Kinematics of Rigid Bodies and Plane Kinetics.

TOTAL : 60 Periods

COURSE OUTCOMES:

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

1. To determine the resultant forces acting on a particle in 2D and 3D and to apply methods of equilibrium on a particle in 2D and 3D.
2. Evaluate the reaction forces for bodies under equilibrium, to determine moment of a force, moment of a couple, to resolve force into a force-couple system and to analyze trusses
3. Assess the centroids of 2D sections / center of gravity of volumes and to calculate area moments of inertia for the sections and mass moment of inertia of solids.
4. Evaluate the frictional forces acting at the contact surfaces of various engineering systems and apply the work-energy principles on a particle. evaluate the kinetic and kinematic parameters of a particle.
5. Determine kinetic and kinematic parameters of the rigid bodies subjected to concurrent coplanar forces.

TEXT BOOKS:

1. Beer Ferdinand P, Russel Johnston Jr., David F Mazurek, Philip J Cornwell, Sanjeev Sanghi, Vector Mechanics for Engineers: Statics and Dynamics, McGraw Higher Education., 12th Edition, 2019.
2. Vela Murali, "Engineering Mechanics-Statics and Dynamics", Oxford University Press, 2018.

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	3	2	3									3		
2	3	3	2	3									3		
3	3	3	2	3									3		
4	3	3	2	3									3		
5	3	3	2	3									3		
Avg	3	3	2	3									3		

UC23H02 தமிழரும் தொழில்நுட்பமும்/Tamils and Technology L T P C
1 0 0 1

அலகு I <u>நெசவு மற்றும் பானைத் தொழில்நுட்பம்</u>: 3

சங்க காலத்தில் நெசவுத் தொழில் – பானைத் தொழில்நுட்பம் – கருப்பு சிவப்பு பாண்டங்கள் – பாண்டங்களில் கீறல் குறியீடுகள்.

அலகு II <u>வடிவமைப்பு மற்றும் கட்டிடத் தொழில்நுட்பம்</u>: 3

சங்க காலத்தில் வடிவமைப்பு மற்றும் கட்டுமானங்கள் & சங்க காலத்தில் வீட்டுப் பொருட்களில் 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 – செட்டிநாட்டு வீடுகள் – பிரிட்டிஷ் காலத்தில் சென்னையில் இந்தோ-சாரோசெனிக் கட்டிடக் கலை.

அலகு III <u>உற்பத்தித் தொழில் நுட்பம்</u>: 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 <u>வேளாண்மை மற்றும் நீர்ப்பாசனத் தொழில் நுட்பம்</u>: 3

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

அலகு V <u>அறிவியல் தமிழ் மற்றும் கணித்தமிழ்</u>: 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 C ivilization on the banks of river Vaigai' (Jointly Published by: Department ofArchaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Publishedby: The Author)
11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Bookand Educational Services Corporation, Tamil Nadu)
12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

TAMILS AND TECHNOLOGY **L T P C**
1 0 0 1

UNIT I WEAVING AND CERAMIC TECHNOLOGY 3

Weaving Industry during Sangam Age – Ceramic technology – Black and Red Ware Potteries (BRW) – Graffiti on Potteries.

UNIT II DESIGN AND CONSTRUCTION TECHNOLOGY 3

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

UNIT III MANUFACTURING TECHNOLOGY 3

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

UNIT IV AGRICULTURE ANDIRRIGATION TECHNOLOGY 3

Dam, Tank, ponds, Sluice, Significance of KumizhiThoompuof Chola Period,Animal Husbandry - Wells designed for cattle use - Agriculture and Agro Processing -KnowledgeofSea -Fisheries – Pearl - Conche diving - Ancient Knowledge ofOcean -KnowledgeSpecificSociety.

UNIT V SCIENTIFIC TAMIL & TAMIL COMPUTING 3

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

TOTAL : 15 PERIODS

TEXT-CUM-REFERENCEBOOKS

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

MA23C03	LINEAR ALGEBRA AND NUMERICAL METHODS	L	T	P	C
		3	1	0	4

OBJECTIVES:

- To understand Vector spaces and its basis and dimension.
- To understand the linear maps between vector spaces and their matrix representations.
- To understand the diagonalizatition of a real symmetric matrix.
- To understand Inner product spaces and its projections.
- To understand numerical techniques for solving linear systems, eigenvalue problems and generalized inverses.

UNIT I VECTORSPACES 9+3

Vector Spaces – Subspaces – Linear Combinations - Linear Span – Linear Dependence - Linear Independence – Bases and Dimensions.

UNIT II LINEAR TRANSFORMATIONS 9+3

Linear Transformation – Null Space, Range Space - Dimension Theorem - Matrix representation of Linear Transformation – Eigenvalues and Eigenvectors of Linear Transformation – Diagonalization of Linear Transformation – Application of Diagonalization in Linear System of Differential Equations.

UNIT III INNER PRODUCT SPACES 9+3

Inner Products and Norms - Inner Product Spaces - Orthogonal Vectors – Gram Schmidt Orthogonalization Process – Orthogonal Complement – Least Square Approximations.

UNIT IV NUMERICAL SOLUTION OF LINEAR SYSTEM OF EQUATIONS 9+3

Solution of Linear System of Equations – Direct Methods: Gauss Elimination Method – Pivoting, Gauss Jordan Method, LU Decomposition Method and Cholesky Decomposition Method - Iterative Methods: Gauss-Jacobi Method, Gauss-Seidel Method and SOR Method.

UNIT V NUMERICAL SOLUTION OF EIGENVALUE PROBLEMS AND GENERALISED INVERSES 9+3

Eigen Value Problems: Power Method – Inverse Power Method – Jacobi's Rotation Method - QR Decomposition - Singular Value Decomposition Method.

TOTAL: 60 PERIODS

Laboratory based exercises / assignments / assessments will be given to students from the content of the course wherever applicable.

Branch specific / General Engineering applications based on the content of each units will be introduced to students wherever possible.

Suggested Laboratory based exercises / assignments / assessments :

1. Linear independence/dependence of vectors
2. Computation of eigenvalues and eigenvectors
3. Diagonalization of Linear Transformation
4. Gram Schmidt Orthogonalization Process
5. Solution of algebraic and transcendental equations
6. Matrix Decomposition methods (LU / Cholesky Decomposition)
7. Iterative methods of Gauss-Jacobi and Gauss-Seidel
8. Matrix Inversion by Gauss-Jordan method
9. Eigen values of a matrix by Power method and by Jacobi's method

10. QR decomposition method
11. Singular Value Decomposition Method

OUTCOMES:

CO1: Solve system of linear equations using matrix operations and vector spaces using Algebraic methods.
CO2: Understand the linear maps between vector spaces and its utilities.
CO3: Apply the concept of inner product of spaces in solving problems.
CO4: Understand the common numerical methods and how they are used to obtain approximate solutions
CO5: Analyse and evaluate the accuracy of common numerical methods.

TEXT BOOKS:

1. Faires, J.D. and Burden, R., “Numerical Methods”, Brooks/Cole (Thomson Publications), Fourth Edition, New Delhi, 2012.
2. Friedberg, S.H., Insel, A.J. and Spence, E., “Linear Algebra”, Pearson Education, Fifth Edition, New Delhi, 2018.
3. Williams, G, “Linear Algebra with Applications”, Jones & Bartlett Learning, First Indian Edition, New Delhi, 2019.

REFERENCES:

1. Bernard Kolman, David R. Hill, “Introductory Linear Algebra”, Pearson Education, First Reprint, New Delhi, 2010.
2. Gerald, C.F, and Wheatley, P.O., “Applied Numerical Analysis”, Pearson Education, Seventh Edition, New Delhi, 2004.
3. Kumaresan, S., “Linear Algebra – A geometric approach”, Prentice – Hall of India, Reprint, New Delhi, 2010.
4. Richard Branson, ''Matrix Operations”, Schaum's outline series, Mc Graw Hill, New York, 1989.
5. Strang, G., “Linear Algebra and its applications”, Cengage Learning, New Delhi, 2005.

CO – PO Mapping:

Course Outcomes	PROGRAMME OUTCOMES											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**P10**	**P11**	**P12**
CO 1 :	3	3	2	3	1	2	1	1	1	1	1	3
CO 2 :	3	3	2	3	1	2	1	1	1	1	1	3
CO 3 :	3	3	2	3	1	2	1	1	1	1	1	3
CO 4 :	3	3	2	3	1	2	1	1	1	1	1	3
CO 5 :	3	3	2	3	1	2	1	1	1	1	1	3

EE23301	ELECTRIC CIRCUIT ANALYSIS	L	T	P	C
		3	0	2	4

UNIT I INTRODUCTION TO DC AND AC CIRCUITS 9L

Types of sources, Independent and Dependent; Ohm's law, Kirchhoff's laws, Mesh, Node, super mesh and Super node analysis.

AC Circuits: Basic definitions; phasors and complex representation; RMS, Average value, form factor, peak factor- AC signals; solution of RLC networks; power, energy relations and power factor calculations. Mesh and Nodal Analysis.

UNIT II NETWORK REDUCTION TECHNIQUES AND NETWORK THEOREMS 9L, 6P

Series parallel circuits; star and delta transformation; Superposition, Reciprocity, Compensation, Thevenin's, Norton's and Maximum Power Transfer Theorems; Analysis with dependent and independent sources-Application to DC and AC networks.

PRACTICALS

1. Network Theorems
    a. Application and experimental verification of network theorems (Thevenin's, Norton's, Superposition, Maximum Power Transfer and Reciprocity theorem).

UNIT III SOLUTION OF FIRST AND SECOND ORDER NETWORKS 9L, 6P

Solution of first and second order differential equations for Series and Parallel R-L, R-C, R-L-C circuits, initial and final conditions in network elements, forced and free response, time constants, steady state and transient state response. Application of Laplace transforms and inverse Laplace transforms for electrical circuits.

PRACTICALS

Circuit Transient and steady state analysis

a. Determination of time constant of series RL, RC circuits.
b. Determination of frequency response of RLC circuits.
c. Steady state analysis of series RL, RC and RLC circuits.

UNIT IV RESONANCE AND TWO PORT NETWORKS 9L,12 P

Resonant circuits-series, parallel, series-parallel circuits-effect of variation of Q on resonance. Relations between circuit parameters- Q, resonant frequency and bandwidth.

Two Port Networks, terminal pairs, relationship of two port variables, impedance parameters, admittance parameters, transmission parameters and hybrid parameters, interconnections of two port networks

PRACTICALS

1. Determination of resonant frequency and bandwidth for Series and Parallel resonant circuits.
2. Determination of impedance, admittance, transmission and hybrid parameters for two port networks.

UNIT V THREE PHASE CIRCUITS 9L, 6P

Three phase balanced / unbalanced circuits, phase sequence – analysis of three phase 3-wire and 4-wire circuits with star and delta connected loads, balanced & un balanced loads – phasor

diagram of voltages and currents – power and power factor measurements in three phase circuits.

PRACTICALS

1. Determination of power in a three phase balanced and unbalanced circuits.

TOTAL: 45L + 30 P= 75 PERIODS

COURSE OUTCOMES:

Upon completion of the course, the students will be able to understand

CO1 the concepts of electrical circuits, fundamental laws and theorems.
CO2 the natural response and the forced response to excitations of the first and second order networks.
CO3 the concepts of complex frequency and its use in relating the forced response and natural response.
CO4 magnetic coupling and two port networks.
CO5 the concepts of poly phase circuits.

TEXT BOOKS:

1. M Nahvi I J A Edminster “Electric Circuits”; Schaum's outline series , Tata McGraw Hill, 4th Edition, 2009
2. Charles K. Alexander, Mathew N.O. Sadiku, “Fundamentals of Electric Circuits”, Fifth Edition, McGraw Hill, 2013.
3. David A Bell ,” Electric circuits “, Oxford University Press, 2011

REFERENCES:

1. Mehdi Rahmani-Andebili, DC Electrical Circuit Analysis, Practice Problems, Methods, and Solution, Springer,2020.
2. Mehdi Rahmani-Andebili, Advanced Electrical Circuit Analysis, Practice Problems,Methods, and Solution, Springer,2020
3. William H. Hayt Jr, Jack E. Kemmerly and Steven M. Durbin, Engineering Circuit Analysis”, Tata McGraw Hill publishers, New Delhi, 2013.
4. Sudhakar. A, Shyammohan. S.P Circuits and Networks-Analysis and Synthesis. TataMcGraw Hill publishers, 5th Edition, 2015.

Mapping COs and POs:																
COs	**POs**												**PSOs**			
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PO12**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**
CO1	3	3	2	3	2	-	-	-	-	-	-	3	3	-	3	2
CO2	3	3	3	3	2	-	-	-	-	-	-	2	2	-	2	3
CO3	2	3	2	3	3	-	-	-	-	-	-	1	3	-	3	2
CO4	3	2	2	3	2	-	-	-	-	-	-	3	2	-	2	3
CO5	3	3	2	2	2	-	-	-	-	-	-	1	3	-	3	3
Avg	2.8	2.8	2.2	2.8	2.2	-	-	-	-	-	-	2	2.6	-	2.6	2.6

EE23302	ELECTROMAGNETIC THEORY	L	T	P	C
		3	0	2	4

UNIT I ELECTROSTATICS I 9L, 6P

Sources, effects and exposure limits of electromagnetic fields, Coordinate systems, Vector calculus- Gradient, Divergence and Curl, theorems and applications, Coulomb's Law – Electric field intensity – Electric Field due to discrete and continuous charges – Gauss's law and applications.

PRACTICALS

Graphical Representation and interpretation of fields (using Mathematical Development Tool) Computation, graphical representation and interpretation of

Vector addition, subtraction, multiplication - dot product and cross product in 2-D and 3-D Gradient fields Divergence fields Curl fields.

UNIT II ELECTROSTATICS II 9L, 6P

Electric potential – Electric fields and equipotential plots, Uniform and Non-Uniform fields, Utilization factor – Electric field in free space, conductors, dielectric -Dielectric polarization – Dielectric strength , Electric fields in multiple dielectrics – Boundary conditions, capacitance, Energy density, Poisson's and Laplace's equations – solutions by Direct Integration method, Applications.

PRACTICALS

Computation of Electric (E) and Magnetic (H) fields (using FEM packages) Problem formulation and Concepts of Finite Element method.

1. Computation of Electric field intensity, voltage distribution and capacitance in Parallel plate capacitor With

- Single dielectric
- Two dielectrics
- Two dielectrics with different angles of interface

2. Computation of Electric field intensity, voltage distribution and capacitance in Coaxial Cable With
- Single dielectric
- Two dielectrics

UNIT III MAGNETOSTATICS 9L, 6P

Lorentz force, magnetic field intensity (H) — Biot– Savart's Law - Ampere's Circuit Law and practical applications— Magnetic flux density (B) – B in free space, conductor, magnetic materials — Magnetization, Magnetic field in multiple media — Boundary conditions, Scalar and vector potential, Poisson's Equation, Magnetic force, Torque, Inductance and mutual inductance, Energy density, Applications.

PRACTICALS

Computation of Magnetic field intensity, inductance in Circular conductor, Circular ring, Solenoid

1. Computation of Force between two conductors

UNIT IV ELECTRODYNAMIC FIELDS 9L, 6P

Magnetic Circuits - Faraday's law – Transformer and motional EMF – Displacement current - Maxwell's equations (differential and integral form) – Time varying potential – Relation between field theory and circuit theory, Applications.

PRACTICALS

1. Computation of E and H fields for practical applications **(Assignment**)

UNIT V ELECTROMAGNETIC WAVES 9L, 6P

Electromagnetic Wave Generation and Wave equations – Wave parameters; velocity, intrinsic impedance, propagation constant – Waves in free space, lossless and lossy dielectrics, conductors-skin depth, Poynting vector, Plane wave reflection and refraction – Standing Wave, Applications.

PRACTICALS

1. Calculation of Skin depth in a circular conductor

Measurement of E and H fields

2. Measurement of Electric Fields (E) using field meter.
3. Measurement of Magnetic fields (H) using field meter.

TOTAL: 45 L +30 PERIODS

LAB COMPONENT: 30 PERIODS

Computation and Analysis of Electromagnetic Fields

I Graphical Representation and interpretation of fields (using Mathematical Development Tool) Computation, graphical representation and interpretation of

Vector addition, subtraction, multiplication - dot product and cross product in 2-D and 3-D Gradient fields Divergence fields Curl fields.

II Computation of Electric (E) and Magnetic (H) fields (using FEM packages) Problem formulation and Concepts of Finite Element method.

2. Computation of Electric field intensity, voltage distribution and capacitance in Parallel plate capacitor With

- Single dielectric
- Two dielectrics
- Two dielectrics with different angles of interface

2. Computation of Electric field intensity, voltage distribution and capacitance in Coaxial Cable With
- Single dielectric
- Two dielectrics

3. Computation of Magnetic field intensity, inductance in Circular conductor, Circular ring, Solenoid
2. Computation of Force between two conductors
3. Calculation of Skin depth in a circular conductor
4. Computation of E and H fields for practical applications **(Assignment**)

III Measurement of E and H fields

Measurement of Electric Fields (E) using field meter.
Measurement of Magnetic fields (H) using field meter.

TOTAL : 75 PERIODS

COURSE OUTCOMES:

Upon completion of the course, the students will be able to

CO1 Apply and analyze the basic mathematical concepts related to electromagnetic fields and identify the electromagnetic sources and their effects.

CO2 Compute and analyze electrostatic fields with practical applications.

CO3 Compute and analyze magneto static fields with practical applications.

CO4 Explain different methods of e.m.f. generation and analyze Maxwell's equations.
CO5 Explain the concept of electromagnetic waves and characterizing parameters.

TEXT BOOKS:

1. Mathew N. O. Sadiku, S.V.Kulkarni,'Principles of Electromagnetics', 6th Edition, Oxford University Press, 2015, Asian Edition.
2. Bhag Singh Guru and Hüseyin R. Hiziroglu "Electromagnetic field theory fundamentals",Cambridge University Press; Second Revised Edition, 2009.
3. Ashutosh Pramanik, 'Electromagnetism – Theory and Applications', PHI Learning Private Limited, New Delhi, Second Edition-2008.

REFERENCES:

1. Joseph. A.Edminister, 'Schaum's Outline of Electromagnetics, Third Edition (Schaum's Outline Series), Tata McGraw Hill, 2010
2. William H. Hayt and John A. Buck, 'Engineering Electromagnetics', Tata McGraw Hill, 8th Revised edition, 2012
3. Kraus and Fleisch, 'Electromagnetics with Applications', McGraw Hill International Editions,Fifth Edition, 2017.
4. Karl E .Lonngren, Sava V. Savov, Randy J. Jost, ' Fundamentals of Electromagnetics with MATLAB", 2nd Edition, PHI Learning Pvt. Ltd., 2009.

Mapping COs and POs:

COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	3	1	2	3	2	1	3	3	2	2	2	2	-	2	2
CO2	3	3	1	2	3	3	2	3	3	2	2	2	2	2	2	3
CO3	3	3	1	2	3	3	2	3	3	2	2	2	2	2	2	3
CO4	3	3	2	2	3	2	2	1	3	2	2	2	2	1	2	1
CO5	3	3	2	2	3	2	1	1	3	2	2	2	2	1	2	1
Avg	3	3	1.4	2	3	2.4	1.6	1.2	3	2	2	2	2	1.5	2	2

EE23303	DIGITAL ELECTRONICS	L	T	P	C
		3	0	2	4

UNIT I NUMBER SYSTEMS, BOOLEAN ALGEBRA AND COMBINATIONAL CIRCUITS 9L10P

Number system, error detection, corrections & codes conversions, Boolean algebra: De-Morgan's theorem, switching functions and minimisation using K-maps & Quine McCluskey method.

PRACTICALS

1. Study of basic digital ICs.
2. Study of code conversion circuits
3. Design of combinational logic circuits

UNIT II DESIGN OF COMBINATIONAL LOGIC CIRCUITS USING GATES AND MSI DEVICES 9L,10P

Design of adder, subtractor, comparators, code converters, encoders, decoders, multiplexers and demultiplexers, Realisation of Boolean Functions using MSI devices, memories and PLA.

PRACTICALS

1. Design of Adder-subtractor circuits using digital IC.
2. Study of decoder circuit
3. Study of demultiplexer circuit
4. BCD to Seven segment code converter and display

UNIT III ANALYSIS AND DESIGN OF SYNCHRONOUS SEQUENTIAL CIRCUITS 9L,10P

Flip flops-- SR, D, JK and T, shift registers, counters, state assignments analysis and design of synchronous sequential circuits, state diagram; state reduction.

PRACTICALS

1. Study of shift registers.
2. Modulo 'n' counter using 7490.
3. Design of synchronous sequential logic circuits.

UNIT IV ANALYSIS AND DESIGN OF ASYNCHRONOUS SEQUENCTIAL CIRCUITS 9L

Latches- SR -D, Asynchronous sequential logic circuits-Transition table, flow table – race conditions – circuits with latches, analysis of asynchronous sequential logic circuits – introduction to design – implication table.

UNIT V LOGIC FAMILIES AND ARITHMETIC CIRCUITS 9L

Logic families : RTL ad DTL circuits ,TTL ECL NMOS and CMOS :Design – Binary adder-4-bit adder IC, Adder/subtractor circuit using adder ICs, concept of carry look ahead, hardware multiplier circuit, Design with Multiplexers / Demultiplexers. Introduction to VHDL.

TOTAL :45 L + 30 P = 75 PERIODS

COURSE OUTCOMES:

Upon completion of the course, the students will be able to

- **CO1** Understand and examine the structure of various number systems and its application in digital design to solve real world problems.
- **CO2** Analyze, design and implement combinational logic circuits using gates.
- **CO3** Analyze, design and implement combinational logic circuits using MSI devices.
- **CO4** Analyze, design and implement synchronous sequential logic circuits using Flip flops and gates.
- **CO5** Analyze and Design Asynchronous sequential logic circuits using Latches and gates.
- **CO6** Design of arithmetic circuits.

TEXT BOOKS:

1. Morris Mano.M, 'Digital Logic and Computer Design', Prentice Hall of India, 3rd Edition, 2005.
2. Donald D. Givone, 'Digital Principles and Design', Tata McGraw Hill, 1st Edition, 2003
3. Thomas L Floyd, 'Digital fundamentals', Pearson Education Limited, 11th Edition, 2015

REFERENCES:

1. Tocci R.J., Neal S. Widmer, 'Digital Systems: Principles and Applications', Pearson EducationAsia, 2014.
2. Donald P Leach, Albert Paul Malvino, Goutam Sha, 'Digital Principles and Applications', Tata McGraw Hill, 7th Edition, 2010

Mapping COs and POs:																
COs	**POs**												**PSOs**			
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**
CO1	2	1	2	3	3	1	-	-	2	-	-	1	3	-	1	3
CO2	2	1	2	3	3	1	-	-	2	-	-	1	3	-	1	3
CO3	2	1	2	3	3	1	-	-	2	-	-	1	3	-	1	3
CO4	2	1	2	3	3	1	-	-	2	-	-	1	3	-	1	3
CO5	2	1	2	3	3	1	-	-	2	-	-	1	3	-	1	3
Avg	2	1	2	3	3	1	-	-	2	-	-	1	3	-	1	3

EE23304	ANALOG ELECTRONICS	L T P C 3 0 2 4

UNIT I **ELECTRONIC DEVICES AND THEIR CHARACTERISTICS** **9L**

PN junction diodes – structure, operation and VI characteristics: drift and diffusion current, transient capacitance – BJT: structure, operation and characteristics; biasing; Introduction to JFET, MOSFET and UJT - Applications.

UNIT II **AMPLIFIER CIRCUITS** **9L, 6P**

BJT small signal model – Analysis of CE amplifier, Gain and Frequency response Differential Amplifier - Two-stage amplifier-Common mode and Differential mode analysis Current mirror circuits - Introduction to internal circuit of typical OPAMPs.

PRACTICALS

1. Transistor based RC phase shift oscillator.

UNIT III **OPAMP AND CHARACTERISTICS** **9L, 6P**

Ideal OPAMP characteristics, DC characteristics, AC characteristics, Voltage-series feedback: non-inverting amplifier and voltage -shunt feedback: inverting amplifier-Frequency response of OPAMP Basic applications: inverting, non- inverting and differential amplifier circuits, Adder-subtractor circuits Differentiation and integrator circuits.

PRACTICALS

1. Op-Amp based amplifier circuits Inverting amplifier.
2. Op-Amp based amplifier circuits Non-inverting amplifier and voltage follower.

UNIT IV **APPLICATION OF OPAMPS** **9L, 12P**

Instrumentation amplifiers, First-order and Second order active filters, V to I and I to V converters, Comparators and multi-vibrators, Waveform generators, Clippers and Clampers, Peak detector, D/A converters (Weighted resistance type and R-2R ladder type), A/D converters (Flash type, Dual slope type, Successive Approximation types and Sigma-Delta type).

PRACTICALS

1. Op-Amp based amplifier circuits Differential amplifier/Instrumentation amplifier.
2. Design of Adder-subtractor circuits using Op-Amp
3. Square wave oscillator
4. Tri-angular wave oscillator.
5. Op-Amp based Wien bridge oscillator.
6. Op-Amp based RC shift oscillator.

UNIT V **SPECIAL ICS** **9L,6P**

555 Timer circuit: Functional block diagram, characteristics & applications – Astable and monostable multivibrator -566 Voltage Controlled Oscillator circuits - PLL Phase Locked Loop applications - Function generator circuit – Linear Voltage regulators.

PRACTICALS

1. 555 – timer IC based astable multi-vibrator.

TOTAL: 45L+30P = 75 PERIODS

COURSE OUTCOMES:

Upon completion of the course, the students will be able to

CO1 understand the structure and underlying semiconductor physics concepts.
CO2 design circuits employing electronic devices.
CO3 understand the characteristics of OPAMP and its internal components.
CO4 analyze, design and implement analog electronic circuits involving OP-AMP.
CO5 analyze, design and implement analog electronic circuits involving timer 555.
CO6 analyze, comprehend and design of analog electronic circuits involving PLL, voltage regulator &other special ICs.

TEXT BOOKS:

1. David A bell, " Electronic circuits" , Oxford University Press, 2011
2. Ramakant A Gayakwad , " Opamps and Linear Integrated Circuits" , IV edition, PearsonEducation/ PHI, 2009.
3. D. Roy Choudary, S.B. Jain, " Linear Integrated Circuits", Third edition, New Age publishers,2014.
4. Donald A Neamen, “Electronic Circuits”, McGraw Hill, edition,2007.

REFERENCES:

1. Millman and Halkias, " Integrated Electronics", McGraw Hill Publications, 2010.
2. Muhammad H. Rashid, " Linear Integrated Circuits", Cengage Learning, 2014.

Mapping COs and POs:

COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	2	1	2	3	3	1	-	-	2	-	-	1	3	-	1	3
CO2	2	1	2	3	3	1	-	-	2	-	-	1	3	-	1	3
CO3	2	1	2	3	3	1	-	-	2	-	-	1	3	-	1	3
CO4	2	1	2	3	3	1	-	-	2	-	-	1	3	-	1	3
CO5	2	1	2	3	3	1	-	-	2	-	-	1	3	-	1	3
Avg	2	1	2	3	3	1	-	-	2	-	-	1	3	-	1	3

UC23U01 **UNIVERSAL HUMAN VALUES** **L T P C**
1 0 2 2

COURSE OBJECTIVE:

The objective of the course is four-fold:

1. Development of a holistic perspective based on self-exploration about themselves (human being), family, society and nature/existence.
2. Understanding (or developing clarity) of the harmony in the human being, family, society and nature/existence
3. Strengthening of self-reflection.
4. Development of commitment and courage to act.

MODULE I: INTRODUCTION (3L,6P)

Purpose and motivation for the course, recapitulation from Universal Human Values-I, Self-Exploration– Its content and process; 'Natural acceptance' and Experiential Validation- as the process for self-exploration Continuous Happiness and Prosperity- A look at basic Human Aspirations Right understanding, Relationship and Physical Facility- the basic requirements for fulfilment of aspirations of every human being with their correct priority Understanding Happiness and Prosperity correctly- A critical appraisal of the current scenario, Method to fulfil the above human aspirations: understanding and living in harmony at various levels.

Practical Session: *Include sessions to discuss natural acceptance in human being as the innate acceptance for living with responsibility (living in relationship, harmony and co-existence) rather than as arbitrariness in choice based on liking-disliking*

MODULE II: HARMONY IN THE HUMAN BEING (3L,6P)

Understanding human being as a co-existence of the sentient 'I' and the material 'Body', Understanding the needs of Self ('I') and 'Body' - happiness and physical facility, Understanding the Body as an instrument of 'I' (I being the doer, seer and enjoyer), Understanding the characteristics and activities of 'I' and harmony in 'I', Understanding the harmony of I with the Body: Sanyam and Health; correct appraisal of Physical needs, meaning of Prosperity in detail, Programs to ensure Sanyam and Health.

Practical Session: *Include sessions to discuss the role others have played in making material goods available to me. Identifying from one's own life. Differentiate between prosperity and accumulation. Discuss program for ensuring health vs dealing with disease.*

MODULE III: HARMONY IN THE FAMILY AND SOCIETY (3L,6P)

Understanding values in human-human relationship; meaning of Justice (nine universal values in relationships) and program for its fulfilment to ensure mutual happiness; Trust and Respect as the foundational values of relationship, Understanding the meaning of Trust; Difference between intention and competence, Understanding the meaning of Respect, Difference between respect and differentiation; the other salient values in relationship, Understanding the harmony in the society (society being an extension of family): Resolution, Prosperity, fearlessness (trust) and co-existence as comprehensive Human Goals, Visualizing a universal harmonious order in society- Undivided Society, Universal Order- from family to world family.

Practical Session*: Include sessions to reflect on relationships in family, hostel and institute as extended family, real life examples, teacher-student relationship, goal of education etc. Gratitude as a universal value in relationships. Discuss with scenarios. Elicit examples from students' lives*

MODULE IV: HARMONY IN THE NATURE AND EXISTENCE (3L,6P)

Understanding the harmony in the Nature, Interconnectedness and mutual fulfilment among the four orders of nature- recyclability and self regulation in nature, Understanding Existence as Co-existence of mutually interacting units in all- pervasive space, Holistic perception of harmony at all levels of existence.

Practical Session: *Include sessions to discuss human being as cause of imbalance in nature (film "Home" can be used), pollution, depletion of resources and role of technology etc.*

MODULE V: IMPLICATIONS OF HARMONY ON PROFESSIONAL ETHICS (3L,6P)

Natural acceptance of human values, Definitiveness of Ethical Human Conduct, Basis for Humanistic Education, Humanistic Constitution and Humanistic Universal Order, Competence in professional ethics: a. Ability to utilize the professional competence for augmenting universal human order b. Ability to identify the scope and characteristics of people friendly and eco-friendly production systems, c. Ability to identify and develop appropriate technologies and management patterns for above production systems. Case studies of typical holistic technologies, management models and production systems, Strategy for transition from the present state to Universal Human Order: a. At the level of individual: as socially and ecologically responsible engineers, technologists and managers b. At the level of society: as mutually enriching institutions and organizations, Sum up.

Practical Session: *Include Exercises and Case Studies will be taken up in Sessions E.g. To discuss the conduct as an engineer or scientist etc.*

TOTAL: 45 (15 Lectures + 30 Practicals) PERIODS

COURSE OUTCOME:

By the end of the course, the students will be able to:

1. Become more aware of themselves, and their surroundings (family, society, nature);
2. Have more responsible in life, and in handling problems with sustainable solutions, while keeping human relationships and human nature in mind.
3. Have better critical ability.
4. Become sensitive to their commitment towards what they have understood (human values, human relationship and human society).
5. Apply what they have learnt to their own self in different day-to-day settings in real life, at least a beginning would be made in this direction.

REFERENCES:

1. Human Values and Professional Ethics by R R Gaur, R Sangal, G P Bagaria, Excel Books, New Delhi, 3rd revised edition, 2023.
2. Jeevan Vidya: Ek Parichaya, A Nagaraj, Jeevan Vidya Prakashan, Amarkantak, 1999.
3. Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 2004.
4. The Story of Stuff (Book).
5. The Story of My Experiments with Truth - by Mohandas Karamchand Gandhi
6. Small is Beautiful - E. F Schumacher.
7. Slow is Beautiful - Cecile Andrews.
8. Economy of Permanence - J C Kumarappa
9. Bharat Mein Angreji Raj - PanditSunderlal
10. Rediscovering India - by Dharampal
11. Hind Swaraj or Indian Home Rule - by Mohandas K. Gandhi
12. India Wins Freedom - Maulana Abdul Kalam Azad

13. Vivekananda - Romain Rolland (English)
14. Gandhi - Romain Rolland (English)

Web URLs:

1. Class preparations: https://fdp-si.aicte-india.org/UHV-II%20Class%20Note.php
2. Lecture presentations: https://fdp-si.aicte-india.org/UHV-II_Lectures_PPTs.php
3. Practice and Tutorial Sessions: https://fdp-si.aicte-india.org/UHV-II%20Practice%20Sessions.php

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1						1	1	1	3			3
CO2						1	1	1	3			3
CO3						3	3	2	3		1	3
CO4						3	3	2	3		1	3
CO5						3	3	3	3		2	3

EE23401	SIGNAL AND SYSTEMS FOR ELECTRICAL ENGINEERS	L	T	P	C
		3	0	2	4

UNIT I CLASSIFICATION OF SIGNALS AND SYSTEM 9

Standard signals- Step, Ramp, Pulse, Impulse, Real and complex exponentials and Sinusoids_ Classification of signals — Continuous time (CT) and Discrete Time (DT) signals, Periodic & Aperiodic signals, Deterministic & Random signals, Energy & Power signals — Classification of systems- CT systems and DT systems- — Linear & Nonlinear, Time-variant & Time-invariant, Causal & Non-causal, Stable & Unstable.

UNIT II ANALYSIS OF CONTINUOUS TIME SIGNALS 9

Continuous-time Fourier series (FS): Periodic signals and their properties, complex exponential as eigen functions of LTI systems, exponential and trigonometric FS representation of periodic signals, convergence, FS of standard periodic signals, salient properties of Fourier series, FS and LTI systems, applications of FS. Continuous-time Fourier transform: Development of Fourier representation of aperiodic signals, convergence, FT of standard signals, FT of periodic signals, properties of FT. relation between Fourier and Laplace transform.

UNIT III LINEAR TIME INVARIANT : CONTINUOUS TIME SYSTEMS 9

Differential Equation-Block diagram representation, transfer function, state space model. Impulse response of an LTI system, convolution integral, graphical convolution, system properties from impulse response, interconnection of LTI systems, evaluating impulse response from the step response, relation between poles and zeros of rational transfer function, frequency response from pole zero locations, zero-state and zero-input response.

UNIT IV ANALYSIS OF DISCRETE TIME SIGNALS 9

Sampling theorem and signal reconstruction, notion of aliasing with examples, discrete-time processing of continuous-time signals, continuous-time processing of discrete-time signals.- DTFT Fourier Transform of discrete time signals (DTFT)- Properties of DTFT- Z Transform & Properties.

UNIT V LINEAR TIME INVARIANT –DISCRETE TIME SYSTEMS 9

Difference Equations-Block diagram representation-Impulse response-Convolution sum-DTFT and Z Transform analysis of Recursive & Non-Recursive systems.

TOTAL: 45 PERIODS

Lab Component for Signals and Systems 30

1. Signal Operations
2. Plotting Magnitude and Space Spectra of signals
3. Signal Analysis and Synthesis
4. Understanding Gibb’s Phenomena by varying series length.
5. Spectra of Aperiodic signal -Fourier Transform and DTFT using coding
6. Effect of sampling above and below Nyquist rate.
7. Poles and Zeros in Z plane
8. To Obtain Fourier series coefficients of signals.
9. To Obtain State Space Model from Transfer function Model
10. Response of system to any test signal given the impulse response

COURSE OUTCOMES:

Upon completion of the course, the students will be able to

CO1 Apply the concepts of continuous time and discrete time systems to analyse systems intime domain

CO2 Understand system stability analysis

CO3 Apply the concepts of continuous time and discrete time systems to analyse systems in frequencydomain

CO4 Understand implications of z-Transform in digitizing in system analysis

CO5 Understand sampling theorem and its implications in during signal reconstruction

TEXT BOOKS

1. A. V. Oppenheim, A. S. Willsky and S. H. Nawab, “Signals and systems”, Prentice Hall India, 1997.
2. B. P. Lathi, “Linear Systems and Signals”, Oxford University Press, 2009.
3. Ingle and Proakis Digital signal Processing using MATLAB-A problem solving Companion”,4th Edition Cengage Learning,2018.

REFERENCES

1. Simon Haykins and Barry Van Veen,, “Signals and Systems”, John Wiley and Sons, 2007
2. H. P. Hsu, “Signals and systems”, Schaum’s series, McGraw Hill Education, 2010.
3. M. J. Robert “Signals and Systems-Analysis using Transform Methods and MATLAB”, McGraw HillEducation,2004
4. M. J. Robert “Fundamentals of Digital signal Processing using MATLAB”, CengageLearning,2005

Mapping COs and POs:

COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	3	3	-	2	2	-	-	2	1	-	3	3	3	3	3
CO2	3	3	3	1	2	2	-	-	2	1	-	3	3	3	3	3
CO3	3	3	3	1	2	2	-	-	2	1	-	3	3	3	3	3
CO4	3	3	3	2	2	-	-	-	2	1	-	3	3	3	3	3
CO5	3	3	3	2	2	-	-	-	2	1	-	3	3	3	3	3
Avg	3	3	3	1.5	2	2	-	-	2	1	-	3	3	3	3	3

EE23402	ELECTRICAL MACHINES - I	L	T	P	C
		3	0	0	3

UNIT I MAGNETIC FIELDS AND MAGNETIC CIRCUITS 9L

Review of magnetic circuits - MMF, flux, reluctance, inductance; review of Ampere Law and Biot Savart Law; Visualization of magnetic fields produced by a bar magnet and a current carrying coil - through air and through a combination of iron and air; influence of highly permeable materials on the magnetic flux lines. Magnetizing current effect of nonlinear B-H curve of magnetic core material, harmonics in magnetising current - permanent magnet and its B-H characteristics.

UNIT II ELECTROMAGNETIC FORCE AND TORQUE 9L

B-H curve of magnetic materials; flux-linkage vs current characteristic of magnetic circuits; linear and nonlinear magnetic circuits; energy stored in the magnetic circuit; force as a partial derivative of stored energy with respect to position of a moving element; torque as a partial derivative of stored energy with respect to angular position of a rotating element. Examples - galvanometer coil, relay contact, lifting magnet, rotating element with eccentricity or saliency.

UNIT III DC MACHINES 9L

Basic construction of a DC machine, magnetic structure - stator yoke, stator poles, pole-faces or shoes, air gap and armature core, visualization of magnetic field produced by the field winding excitation with armature winding open, air gap flux density distribution, flux per pole, induced EMF in an armature coil. Armature winding and commutation – Elementary armature coil and commutator, lap and wave windings, construction of commutator, linear commutation - Derivation of back EMF equation,armature MMF wave, derivation of torque equation, armature reaction, air gap flux density distribution with armature reaction.

UNIT IV DC MACHINE - MOTORING AND GENERATION 9L

Armature circuit equation for motoring and generation, Types of field excitations – separately excited, shunt and series. Open circuit and load characterisitics of separately excited DC generator, back EMF with armature reaction, voltage build-up in a shunt generator, critical field resistance and critical speed - Starters for DC motors - and torque-speed characteristics of separately excited, shunt and series motors. Speed control through armature voltage and field current. - Braking of DC motors - Losses and efficiency - Swinburne's and Hopkinson tests, direct load test and temperature rise test of DC machines.

UNIT V TRANSFORMERS 9L

Principle, construction and operation of single-phase transformers, equivalent circuit, phasor diagram, voltage regulation, losses and efficiency. Testing - open circuit and short circuit tests, polarity test, back-to-back test, separation of hysteresis and eddy current losses. Three-phase transformer- construction, types of connection and their comparative features, Parallel operation of single-phase and three-phase transformers, Autotransformers – construction, working principle, applications and comparison with two winding transformer, Phase conversion - Scott connection, three-phase to six-phase conversion, Tap-changing transformers - No-load and on-load tap-changing of transformers, Three-winding transformers, Cooling of transformers.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

After completion the above subject, students will be able to

CO1 Understand the concepts of magnetic circuits.

CO2 Understand the principles of induced emf's in stationary and torque in rotating machines.

CO3 Understand the operation of DC machines.

CO4 Analyse the differences in operation of different DC machine configurations.

CO5 Understand the construction and analyse the performance of single phase and multi-phase transformers.

TEXT BOOKS:

1. A. E. Fitzgerald and C. Kingsley, "Electric Machinery", New York, McGraw Hil Education, 2013.
2. P. C. Sen, "Principles of Electric Machines and Power Electronics", John Wiley & Sons,Third Edition (Adapted Indian Edition).
3. P. S. Bimbhra, "Electrical Machinery", Khanna Publishers, 2011.
4. I. J. Nagrath and D. P. Kothari, "Electric Machines", McGraw Hill Education, 2010.

REFERENCES:

1 H. Cotton, "Electrical Technology", CBS PUBLISHERS AND DISTRIBUTORS, 2018

2 A. E. Clayton and N. N. Hancock, "Performance and Design of DC machines", CBS Publishers and Distributors, 2018

3 M. G. Say, "Performance and design of AC machines", CBS Publishers, 2002.

Mapping COs and POs:

COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	3	1	3	2	-	-	2	-	-	2	2	3	-	3	3
CO2	3	3	1	3	3	-	-	2	-	-	2	2	3	-	3	3
CO3	3	3	1	3	3	-	-	2	-	-	2	2	3	1	3	3
CO4	3	3	1	3	3	-	-	2	-	-	2	2	3	-	3	3
CO5	3	3	1	3	3	-	3	2	-	-	2	2	3	1	3	3
Avg	3	3	1	3	3	-	3	2	-	-	2	2	3	1	3	3

EE23403	MEASUREMENT AND INSTRUMENTATION	L	T	P	C
		3	0	2	4

UNIT I MEASUREMENT CONCEPTS AND ANALOG INSTRUMENTS 9

Instruments: classification, applications – Elements of a generalized measurement system - Static and dynamic characteristics - Errors in measurement -Statistical evaluation of measurement data. Classification of instruments – moving coil and moving iron meters – Induction type, dynamometer type meters – Energy meter – Mega Ohm Meter - Instrument transformers (CT & PT).

UNIT II TRANSDUCERS AND ACTUATORS 9

Principles: Resistive – Inductive – Capacitive - Magnetic sensing - Piezoelectric effects – Light - Temperature based sensing, Classification of transducers – Measurement of pressure, temperature, displacement, flow, angular velocity – Digital transducers – Smart Sensors, Actuators: Principle – Classification: Pneumatic, mechanical, electrical, magnetic and thermal – applications

UNIT III AC/DC BRIDGES AND INSTRUMENTATION AMPLIFIERS 9

Wheatstone bridge, Kelvin double bridge Maxwells, Hay, Wien and Schering bridge – Errors and compensation in A.C. bridges Instrumentation Amplifiers.

UNIT IV DIGITAL INSTRUMENTATION 9

A/D converters: types and characteristics – Sampling, Errors- Measurement of voltage, Current, frequency and phase - D/A converters: types and characteristics- DSO- Data Loggers –Instrument standards.

UNIT V PLC AND VIRTUAL INSTRUMENTATION 9

Evolution of PLC – Sequential and Programmable controllers – Architecture – Programming of PLC – Functional blocks – Communication Networks for PLC. Introduction to Virtual Instrumentation (VI) – Architecture – Programming – Front Panel and Block diagram – Data flow programming – G programming concepts – Control structures – Error handling – String controls – File I/O VIs and functions.

TOTAL: 45 PERIODS

LAB COMPONENT 30

1. Static and Dynamic characteristics of Electrical and Non electrical transducers.
2. Design a resistive, capacitive and inductive Bridges to measure the unknown physical parameter.
3. Design an Instrumentation amplifier to amplify the output obtained from a transducer.
4. Design A/D and D/A converters to interface the analog system with the digital platform
5. Calibration of analog instruments.
6. Calibration of digital instruments
7. Study of characteristics of Optical Sensors
8. PLC programming for Process Control Applications
9. Development of GUI application for Process Control
10. Demonstration of PC based data acquisition with complete closed loop control including sensor and actuator dynamics

TOTAL : 75 PERIODS

COURSE OUTCOMES:

After completion the above subject, students will be able to

- **CO1** understand the concepts of measurement and the structural elements of various analog instruments.
- **CO2** Understand the principles involved in transducers and actuators.
- **CO3** Design the signal conditioning circuits for various transducers.
- **CO4** Develop interfacing circuits with the concepts of digital instrumentation.
- **CO5** Develop the programs using PLC and virtual instrumentation for a physical system.

TEXT BOOKS:

1. A.K. Sawhney, Puneet Sawhney 'A Course in Electrical & Electronic Measurements & Instrumentation', Dhanpat Rai and Co, New Delhi, Edition 2015.
2. H.S. Kalsi, 'Electronic Instrumentation and Measurements', Tata McGraw-Hill, New Delhi, 2019
3. Albert D. Helfrick & William D. Cooper, "Modern Electronic Instrumentation and Measurement Techniques", Prentice Hall India Learning Private Limited, 1992
4. Dag H. Hanssen, Programmable Logic Controllers, A Practical Approach to IEC 61131-3 using CODESYS, John Wiley & Sons Ltd., 2015
5. Labview based Advanced Instrumentation systems, S. Sumathi & P. Surekha, Springer Publications, 2018 Edition.

REFERENCES:

1. M.M.S. Anand, 'Electronics Instruments and Instrumentation Technology', Prentice Hall India, New Delhi, 2009 J.J.
2. Carr, 'Elements of Electronic Instrumentation and Measurement', Pearson Education India, New Delhi, 2011
3. W.Bolton, Programmable Logic Controllers, 5th Ed, Elseiver, 2010.
4. R.B. Northrop, 'Introduction to Instrumentation and Measurements', Taylor & Francis, New Delhi, 2008
5. E. O. Doebelin and D. N. Manik, "Measurement Systems – Application and Design", Tata McGraw-Hill, New Delhi, 2007
6. R. K. Rajput, "Electrical and Electronics Measurements and Instrumentation", Chand Pub, 2016.
7. J.B. Gupta, "Electrical Measurements & Measuring Instruments", S.K. Kataria & Sons, 2020

Mapping COs and POs:

COs	POs												PSOs			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	3	-	-	2	-	2	-	-	-	3	3	3	3	3
CO2	3	3	3	3	-	2	-	-	3	-	3	3	3	3	3	3
CO3	3	3	3	3	3	2	-	-	3	-	3	3	3	3	3	3
CO4	3	3	3	3	3	2	-	2	3	-	3	3	3	3	3	3
CO5	3	3	3	3	3	2	-	-	3	-	3	3	3	3	3	3
Avg	3	3	3	2.4	1.8	2	-	2	2.4	-	2.4	3	3	3	3	3

EE23404 MICROPROCESSORS AND MICROCONTROLLERS L T P C
3 0 2 4

UNIT I INTRODUCTION TO 8085 ARCHITECTURE 9

Functional block diagram – Memory interfacing – I/O ports and data transfer concepts – Timing Diagram – Interrupt structure.

UNIT II 8085 INSTRUCTION SET AND PROGRAMMING 9L,6P

Instruction format and addressing modes – Assembly language format – Data transfer, data manipulation & control instructions – Programming: Loop structure with counting & Indexing- Look up table – Subroutine - stack.

PRACTICALS

1. Simple arithmetic operations with 8085: Multi precision addition / subtraction /multiplication / division.
2. Programming with control instructions: Increment / Decrement, Ascending / Descending order, Maximum / Minimum of numbers, rotate instructions, Hex / ASCII / BCD code conversions.

UNIT III INTERFACING BASICS AND ICS 9L, 6P

Study of Architecture and programming of ICs: 8255 PPI, 8259 PIC, 8251 USART, 8279 Key board display controller and 8254 Timer/ Counter – Interfacing with 8085 - A/D and D/A converter interfacing.

PRACTICALS

1. Interface Experiments: D/A Interfacing
2. Interface Experiment: Traffic light controller.
3. Interface Experiment: Stepper motor controller interface.

UNIT IV INTRODUCTION TO 8051 MICROCONTROLLER 9L,12P

Functional block diagram - Instruction format and addressing modes – Interrupt structure – Timer –I/O ports – Serial communication, Simple programming- key board and display interface – Temperature control system - stepper motor control Usage of IDE for assembly language programming.

PRACTICALS

1. Simple arithmetic operations with 8051: Multi precision addition / subtraction /multiplication / division.
2. Programming with control instructions: Increment / Decrement, Ascending / Descending order, Maximum / Minimum of numbers, rotate instructions, Hex / ASCII / BCD code conversions.
3. Interface Experiments: Involving DAC and ADC interface.
4. Interface Experiment: Stepper Motor Controller Interface.

UNIT V INTRODUCTION TO ADVANCED ARCHITECTURE 9L,6P

ARM Cortex-M series – overview - Programmer's Model - Memory System Overview - System Control B lock - Microcontroller Start sequence – Ports: interfacing and programming.

PRACTICALS

ARM I/O interfacing experiments

TOTAL:45 L + 30 P = 75 PERIODS

COURSE OUTCOMES:

Upon completion of the course, the students will be

CO1 Ability to write assembly language program for microprocessor and microcontroller.

CO2 Ability to comprehend, design and simulate microprocessor based systems used for control and monitoring.

CO3 Ability to analyze, design and implement interfacing of peripheral with microprocessor.

CO4 Ability to analyze, comprehend, design and simulate microcontroller based systems used for control and monitoring.

CO5 Ability to understand and appreciate advanced architecture evolving microprocessor architecture.

TEXT BOOKS:

1. Ramesh S. Gaonkar, 'Microprocessor Architecture Programming and Application', Penram International (P) ltd., Mumbai, 5 th edition, 2008.
2. Muhammad Ali Mazidi & Janice Gilli Mazidi, 'The 8051 Micro Controller and Embedded Systems', Pearson Education, 2007.
3. Joseph Yiu , 'The Definitive Guide to the ARM Cortex-M0' Newnes – Elsevier, 2011.
4. Kenneth Ayala, "The 8051 Microcontroller", Cengage Learning India, 2007, 3rd Edition.

REFERENCES:

1. Douglas V. Hall, "Micro-processors & Interfacing". Tata McGraw Hill 2nd edition, 2009.
2. Krishna Kant, "Micro-processors & Micro-controllers", Prentice Hall of India, 2007.
3. Embedded Systems: Architecture, Programming & Design, Raj Kamal, 2008, Tata McGraw Hill
4. Raj Kamal, "Embedded Systems: Architecture, Programming & Design", McGraw Hill Education, 2008
5. Mike Predko, " 8051 Micro-controller", McGraw Hill, 2009
6. Kenneth Ayala, 'The 8051Microcontroller', Thomson, 2005.
7. Muhammad Tahir and Kashif Javed, 'ARM Microprocessor Systems - Cortex-M Architecture, Programming, and Interfacing', CRC Press, 2011.
8. Muhammad Ali Mazidi, "ARM Assembly Language Programming & Architecture", Microdigitaled, 2nd edition, 2016.

Mapping COs and POs:

COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	1	2	3	3	1	-	-	2	-	-	1	3	-	1	3
CO2	2	1	2	3	3	1	-	-	2	-	-	1	3	-	1	3
CO3	2	1	2	3	3	1	-	-	2	-	-	1	3	-	1	3
CO4	2	1	2	3	3	1	-	-	2	-	-	1	3	-	1	3
CO5	2	1	2	3	3	1	-	-	2	-	-	1	3	-	1	3
Avg	2	1	2	3	3	1	-	-	2	-	-	1	3	-	1	3

EE23405	TRANSMISSION AND DISTRIBUTION	L	T	P	C
		3	0	0	3

UNIT I STRUCTURE OF POWER SYSTEM 9

Structure of electric power system: generation, transmission and distribution; Choice of transmission voltage, overhead and underground systems, Types of AC and DC distributors–distributed and concentrated loads–voltage tolerances, interconnection-advantages and limitations–EHVAC and HVDC transmission - Introduction to FACTS devices.

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, conductor types - Symmetrical and unsymmetrical spacing and transposition-application of self and mutual GMD; skin and proximity effects-Effects of earth on capacitance of transmission line - interference with neighboring communication circuits, corona discharge, factors affecting corona-advantages and disadvantages.

UNIT III MODELLING AND PERFORMANCE OF TRANSMISSION LINES 9

Classification of lines–short line, medium line and long line-Evaluation of A,B,C,D constants- equivalent circuits, phasor diagram, attenuation constant, phase constant, surge impedance and surge impedance loading; transmission efficiency and voltage regulation, real and reactive power flow in lines, Power-circle diagrams, methods of voltage control ;Ferranti effect, Charging current and losses in an open circuited line.

UNIT IV INSULATORS AND CABLES 9

Main components of overhead lines-Insulators-Types, voltage distribution in insulator string, improvement of string efficiency, Underground cables-Types of cables, insulation materials, Parameters of cable, Grading of cables, Capacitance of 3-core cable, heating, thermal resistance of cables.

UNIT V MECHANICAL DESIGN OF LINES AND GROUNDING 9

Mechanical design of transmission line, sag and tension calculations for different weather conditions, Tower spotting, Types of towers, Sub-station Layout (AIS, GIS), Methods of grounding – Substation and Building.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, the students will be able to

- **CO1** understand structure of power system with different voltage levels.
- **CO2** compute line parameters for different configurations.
- **CO3** model transmission line and to determine the performance of line.
- **CO4** choose various insulators and cables for transmission and distribution.
- **CO5** carry out mechanical design of transmission line and grounding.

TEXT BOOKS:

1. S.N.Singh, ‘Electric Power Generation ,Transmission and Distribution’, Prentice Hall of India Pvt.Ltd, New Delhi, 2008.
2. B.R.Gupta,‘ Power System Analysis and Design’, S.Chand, New Delhi, Fifth Edition 2005-08.

REFERENCES:

1. R.K.Rajput, 'Power System Engineering' Laxmi Publications (P) Ltd, New Delhi, 2006
2. D.P.Kothari, I.J.Nagarath, 'Power System Engineering' Tata Mc Graw -Hill Publishing Company limited, New Delhi, 2007.
3. C.L.Wadhwa, 'Electrical Power Systems', New Academic Science Ltd, 2009
4. Luces M.Fualkenberry ,Walter Coffer, 'Electrical Power Distribution and Transmission', Pearson Education, 2007.
5. HadiSaadat, 'Power System Analysis, 'PSA Publishing; Third Edition, 2010.
6. J.Brian, Hardy and Colin R.Bayliss' Transmission and Distribution in Electrical Engineering',Newnes;FourthEdition,2012.
7. Gorti Ramamurthy ,"Transmission and Distribution", Hand book of Electrical PowerDistribution, 2009, Universities Press.

Mapping COs and POs:

COs	POs												PSOs			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	2	2	-	-	1	2	-	-	1	-	-	2	-	1	-
CO2	3	2	2	-	-	1	2	-	-	1	-	-	2	3	1	-
CO3	3	2	2	-	-	1	2	-	-	1	-	-	2	3	1	-
CO4	3	2	2	-	-	1	2	-	-	1	-	-	2	-	1	-
CO5	3	2	2	-	-	1	2	-	-	1	-	-	2	-	1	-
Avg	3	2	2	-	-	1	2	-	-	1	-	-	2	3	1	-

EE23406 **ELECTRICAL MACHINES LABORATORY – I**

L	T	P	C	P
0	0	4	2	4

LIST OF EXPERIMENTS

- Open circuit and load characteristics of a separately excited DC Generator
- Study of starters of DC motors
- Speed control of DC shunt motor
- Load test on DC shunt motor.
- Load test on DC series motor
- Load test of DC compound motor
- Swinburne's test.
- Hopkinson's Test.
- Open circuit and short circuit test on single-phase transformer.
- Separation of no-load losses in a single phase transformer.
- Sumpner's test to determine the temperature rise of transformers
- Connections of multi-phase transformers.
- Scott Connection for Phase Conversion of Transformers

TOTAL: 60 PERIODS

COURSE OUTCOMES:

After completion of the above subject, students will be able to

CO1 Understand the Steady State Performance characteristics of DC machines and Transformers.
CO2 Understand the Speed control of DC shunt motor above and below rated speed.
CO3 Understand the need for DC motor starters and Three phase transformer connections.
CO4 Estimate and analyse the performance of Electrical Machines.
CO5 Compare and study the performance of different types of DC machines.

Mapping COs and POs:

COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	-	-	-	3	-	-	-	-	-	-	-	-	1	3	-	-
CO2	-	-	3	3	-	-	-	-	-	-	-	-	1	3	2	-
CO3	-	3	2	1	2	-	-	-	-	-	-	-	1	3	2	-
CO4	-	3	2	2	3	-	-	-	-	-	-	-	1	3	2	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	1	3	2	3
Avg	-	3	2.3	2.25	2.5	-	-	-	-	-	-	-	1	3	2	3

SEMESTER V

EE23501	ELECTRICAL MACHINES – II	L	T	P	C
		3	0	0	3

UNIT I FUNDAMENTALS OF AC MACHINE WINDINGS 9

Physical arrangement of windings in stator and cylindrical rotor; slots for windings; single turn Coil – active portion and overhang; full-pitch coils, concentrated winding, distributed winding, Winding axis, 3D visualization of the above winding types, Air-gap MMF distribution with fixed Current through winding - concentrated and distributed, Sinusoidally distributed winding, Winding factor.

UNIT II PULSATING AND REVOLVING MAGNETIC FIELDS 9

Constant magnetic field, pulsating magnetic field – alternating current in windings with Spatial displacement, Magnetic field produced by a single winding – fixed current and Alternating current Pulsating fields produced by spatially displaced windings, Windings Spatially shifted by 90 degrees, Addition of pulsating magnetic fields, Three windings spatially shifted by 120 degrees (carrying three-phase balanced currents), revolving magnetic field.

UNIT III INDUCTION MACHINES 9

Construction, Types (squirrel cage and slip-ring), Torque Slip Characteristics, Starting - Cogging and Crawling - Maximum Torque. Equivalent circuit, Circle Diagram - Losses and Efficiency. Effect of parameter variation on torque speed characteristics (variation of rotor and stator resistances, stator voltage, frequency). Methods of starting, braking and speed control for induction motors. Generator operation. Self- excitation. Doubly-Fed Induction Machines.

UNIT IV SYNCHRONOUS MACHINES 9

Constructional features, cylindrical rotor synchronous machine - generated EMF, equivalent circuit and phasor diagram, armature reaction, synchronous impedance, voltage regulation and pre-determination methods. Operating characteristics of synchronous machines, V-curves. Salient pole machine – two reaction theory, analysis of phasor diagram, power angle characteristics. Capability curves - Synchronization and load division. Parallel operation of alternators.

UNIT V SINGLE PHASE INDUCTION MOTORS AND SPECIAL ELECTRIC MOTORS 9

Constructional features, double revolving field theory, equivalent circuit, determination of parameters. Split-phase starting methods and applications. Construction and working principle of PMSM and BLDC machines, Bureau of Indian Standards of Rotating Machines.

TOTAL: 45 PERIODS

NOTE: The question paper for this course can be set with weightage of marks distribution as per the distribution of contact periods.

COURSE OUTCOMES:

After completion the above subject, students will be able to

- **CO1** Understand the concepts of windings, MMFs and rotating magnetic fields.
- **CO2** Understand the operation of AC machines.
- **CO3** Analyse the performance characteristics of AC machines.
- **CO4** Analyse the starting and speed control of AC machines.
- **CO5** Understand the standards and field applications of AC machines.

TEXT BOOKS:

1 A. E. Fitzgerald and C. Kingsley, "Electric Machinery", McGraw Hill Education, 2013.
2 P. C. Sen, "Principles of Electric Machines and Power Electronics", John Wiley & Sons,Third Edition (Adapted Indian Edition).
3 P. S. Bimbhra, "Electrical Machinery", Khanna Publishers, 2011.
4 I. J. Nagrath and D. P. Kothari, "Electric Machines", McGraw Hill Education, 2010.

REFERENCES:

1 M. G. Say, "Performance and Design of AC machines", CBS Publishers, 2002.
2 A. S. Langsdorf, "Alternating current machines", McGraw Hill Education, 1984.

Mapping COs and POs:																
COs	**POs**												**PSOs**			
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**
CO1	2	-	3	2	1	1	-	2	-	-	-	-	-	3	-	3
CO2	3	-	3	3	1	3	-	-	-	-	-	-	-	3	1	3
CO3	3	-	3	3	1	3	-	-	-	-	3	3	-	3	2	3
CO4	3	-	3	3	1	3	-	-	-	-	3	3	-	3	-	3
CO5	3	-	3	3	1	3	-	-	-	-	3	3	-	3	-	3
Avg	2.8	-	3	2.8	1	2.6	-	2	-	-	-	-	-	3	1.5	3

EE23502	CONTROL SYSTEMS DESIGN	L	T	P	C
		3	0	2	4

UNIT I MODELING OF LINEAR TIME INVARIANT (LTIV) SYSTEMS 9

Open loop and Closed loop systems – Feedback control system characteristics – First principle modeling: Mechanical, Electrical and Electromechanical systems – Transfer function representations: Block diagram and Signal flow graph.

PRACTICALS

1. Mathematical modelling and analysis of Mechanical and Electrical systems using transfer function approach

UNIT II TIME DOMAIN ANALYSIS 9

Standard test inputs – Time responses – Time domain specifications – Stability analysis: Concept of stability – Routh Hurwitz stability criterion – Root locus: Construction and Interpretation. Effect of adding poles and zeros.

PRACTICALS

1. Time domain analysis of second order system
2. Study of stability using Routh Hurwitz criterion
3. Root locus technique based stability analysis

UNIT III FREQUENCY DOMAIN ANALYSIS 9

Frequency domain specifications, Bode plot, Polar plot and Nyquist plot - Introduction to closed loop Frequency Response.

PRACTICALS

1. Frequency response and stability analysis using Bode plot
2. Frequency response and stability analysis using Polar plot

UNIT IV STATE VARIABLE ANALYSIS 9

State variable formulation – Non uniqueness of state space model – State transition matrix – Eigen values – Eigen vectors - Free and forced responses for Time Invariant Systems – Controllability – Observability.

PRACTICALS

1. Mathematical modelling and analysis of Mechanical and Electrical systems using state space approach
2. Test of controllability and observability of a state space model

UNIT V DESIGN OF FEED BACK CONTROL SYSTEM 9

Design specifications – Lead, Lag and Lag-lead compensators using Bode plot – PID controller-Design using reaction curve and Ziegler-Nichols technique- PID control in State Feedback form.

PRACTICALS

1. Design of compensators using Bode plot
2. Design of P, PI, PD and PID controllers and evaluation of closed loop system performance for a second order system

TOTAL: 45 L + 30 P = 75 PERIODS

COURSE OUTCOMES:

Upon completion of the course, the students will be able to

CO1 Represent the physical systems using transfer function approach.
CO2 Analyse and evaluate the performance of systems in time domain.
CO3 Analyse and evaluate the performance of systems in frequency domain.
CO4 Analyse the simple systems using state space approach.
CO5 Design and evaluate the performance of closed loop systems with compensators

TEXT BOOKS:

1. Nagrath.I.J & Gopal.M, "Control Systems Engineering", New Age International Pvt. Ltd., 7th Edition, 2021.
2. Katsuhiko Ogata, "Modern Control Engineering", Pearson, 5th Edition, 2015.

REFERENCES:

1. Richard C.Dorf and Bishop, R.H., "Modern Control Systems", Education Pearson, 13th Edition, 2017.
2. John J.D., Azzo Constantine, H. and Houpis Sttuart, N Sheldon, "Linear Control System Analysis and Design with MATLAB", CRC Taylor & Francis Reprint 2009.
3. Farid Golnaraghi & Benjamin C. Kuo, "Automatic Control System", Wiley, 9th Edition, 2010.

Mapping COs and POs:																
COs	**POs**												**PSOs**			
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO1 0**	**PO1 1**	**PO1 2**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**
CO1	3	2	2	-	3	-	-	-	3	-	-	1	3	2	3	1
CO2	3	3	2	-	3	-	-	-	3	-	-	1	2	2	3	1
CO3	3	3	2	-	3	-	-	-	3	-	-	1	2	2	3	1
CO4	3	3	2	-	3	-	-	-	3	-	-	1	2	2	3	1
CO5	3	3	3	-	3	-	-	-	3	-	-	1	2	3	3	1
Avg	3	2.8	2.2	-	3	-	-	-	3	-	-	1	2.2	2.2	3	1

EE23503 **POWER SYSTEM ANALYSIS** **L T P C**
3 0 2 4

UNIT I **POWER SYSTEM OVERVIEW** **9L, 6P**

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

PRACTICALS

1. Construction of bus admittance matrix
2. Power system expansion planning studies

UNIT II **POWER FLOW ANALYSIS** **9L,6P**

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

PRACTICALS

1. Solving power flow problem using Gauss-Seidel method
2. Solving power flow problem using N-R method

UNIT III **SYMMETRICAL FAULT ANALYSIS** **9L,6P**

Importance of short circuit studies - Assumptions in short circuit analysis - Symmetrical short circuit analysis using Thevenin's theorem - Bus Impedance matrix by building algorithm - Symmetrical fault analysis through bus impedance matrix - Post fault bus voltages - Fault level Current limiting reactors.

PRACTICALS

1. Bus impedance matrix
2. Symmetric short circuit analysis

UNIT IV **UNSYMMETRICAL FAULT ANALYSIS** **9L,6P**

Symmetrical components - Sequence impedances – Sequence circuits of synchronous machine, transformer and transmission line-Sequence networks--Analysis of unsymmetrical faults: single-line- to-ground, line-to-line and double-line-to-ground using Thevenin's theorem - computation of post fault currents in symmetrical component and phasor domains.

PRACTICALS

1. LG fault analysis using symmetrical components
2. LL fault analysis using symmetrical components
3. LLG fault analysis using symmetrical components

UNIT V **STABILITY ANALYSIS** **9L,6P**

Importance of stability studies-Classification of power system stability: rotor angle stability and voltage stability –Single Machine Infinite Bus (SMIB) system: Development of swing equation - solution of the swing equation - Equal area criterion - Critical clearing angle and time – Runge-Kutta fourth order method.

PRACTICALS

1. Transient Stability analysis using Runge-Kutta fourth order method

TOTAL : 45 L+30P = 75 PERIODS

COURSE OUTCOMES:

After completion of the above subject, students will be able to

CO1 Model the various power system components for steady-state analysis.
CO2 Carry out the power flow analysis by Gauss-Seidel and Newton-Raphson methods.
CO3 Conduct the fault analysis of power system for balanced faults.
CO4 Carry out the short circuit analysis of the power system for unbalanced faults using symmetrical component theory.
CO5 Compute the stability of the system with the help of equal area criteria and Modified-Euler and Runge-Kutta fourth order methods.

TEXT BOOKS:

1. John J. Grainger, William D. Stevenson, Jr, 'Power System Analysis', Mc Graw Hill Education (India) Private Limited, New Delhi, 2015.
2. Kothari D.P. and Nagrath I.J., 'Power System Engineering', Tata McGraw-Hill Education, SecondEdition, 2008.

REFERENCES

1. Hadi Saadat, 'Power System Analysis', Tata McGraw Hill Education Pvt. Ltd., New Delhi, 21st reprint, 2010.
2. Pai M A, 'Computer Techniques in Power System Analysis', Tata Mc Graw-Hill Publishing Company Ltd., New Delhi, Second Edition, 2007.
3. J. Duncan Glover, Mulukutla S.Sarma, Thomas J. Overbye, 'Power System Analysis & Design', Cengage Learning, Fifth Edition, 2012.
4. Gupta B.R., 'Power System - Analysis and Design', S. Chand Publishing, 2001.
5. Kundur P., 'Power System Stability and Control', Tata McGraw Hill Education Pvt. Ltd., New Delhi,10th reprint, 2010.

Mapping COs and POs:

COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	2	2	1	1	-	-	-	1	-	-	1	3	-	1	-
CO2	3	2	2	1	1	-	-	-	1	-	-	1	3	-	1	-
CO3	3	2	2	1	1	-	-	-	1	-	-	1	3	-	1	-
CO4	3	2	2	1	1	-	-	-	1	-	-	1	3	-	1	-
CO5	3	2	2	1	1	-	-	-	1	-	-	1	3	-	1	-
Avg	3	2	2	1	1	-	-	-	1	-	-	1	3	-	1	-

EE23504	POWER ELECTRONICS	L T P C 3 0 2 4

UNIT I SINGLE PHASE RECTIFIERS 9L,6P

Power Diode – half wave rectifier – mid-point secondary transformer based full wave rectifier – bridge rectifier - distortion factor - LC filters – SCR-Two transistor analogy based turn- ON, Controlled converters (1 pulse, 2 pulse) displacement factor – ripple and harmonic factor effect of source inductance, inverter angle limit.

PRACTICALS

1. Characteristics of SCR
2. Simulation of Single Phase Rectifiers

UNIT II THREE PHASE RECTIFIERS 9L,6P

Three phase diode rectifiers – Concern for power quality, Controlled converters (3 pulse, 6 pulse) Computation of performance parameters.

PRACTICALS

1. Experimental verification of transfer characteristic of AC to DC half controlled converter
2. Experimental verification of transfer characteristic of of AC to DC fully controlled Converter
3. Simulation of Three Phase Rectifiers

UNIT III SWITCHING POWER SUPPLIES 9L,6P

IGBT, MOSFET: dynamic behaviour - driver and snubber circuits -low power high switching frequency switching Power supplies, buck, boost, buck-boost converters – Isolated topologies – resonant converters switching loss calculations and thermal design.

PRACTICALS

1. Experimental verification of transfer characteristic of MOSFET based Step down and step up choppers
2. Characteristics of MOSFET and IGBT
3. Simulation of Switching Power Supplies

UNIT IV INVERTERS 9L,6P

Single phase half bridge and full bridge inverters - VSI :(1phase and three phase inverters square wave operation) - Voltage control of inverters single, multi pulse, sinusoidal, space vector modulation techniques– various harmonic elimination techniques-CSI.

PRACTICALS

1. Experimental verification of operation of IGBT based single and three phase PWM inverter
2. Simulation of Inverters

UNIT V AC PHASE CONTROLLERS 9L,6P

TRIAC triggering concept with positive and negative gate pulse triggering, TRIAC based phase controllers various configurations for SCR based single and three phase controllers.

PRACTICALS

1. Characteristics of TRIAC
2. Experimental verification of transfer characteristics of AC Phase Controllers

TOTAL 45 L+ 30P = 75 PERIODS

COURSE OUTCOMES:

After completion the above subject, students will be able to

- **CO1** To understand operation of semiconductor devices, its dynamic characteristics and to design &analyze low power SMPS.
- **CO2** Analyze the various uncontrolled rectifiers and design suitable filter circuits.
- **CO3** Analyze the operation of the n-pulse converters and evaluate the performance parameters.
- **CO4** Understand various PWM techniques and apply voltage control and harmonic elimination methods to inverter circuits
- **CO5** Understand operation of AC voltage controllers and its applications

TEXT BOOKS:

1. Ned Mohan, T.M.Undeland, W.P.Robbins, ”Power Electronics: Converters, applications and design”, John Wiley and Sons, 3rd Edition (reprint), 2009
2. Rashid M.H., Power Electronics Circuits, Devices and Applications, Prentice Hall India, 3 rd Edition, New Delhi, 2004.

REFERENCES:

1. Cyril.W.Lander, Power Electronics, McGraw Hill International, Third Edition, 1993.
2. P.S.Bimbhra, Power Electronics, Khanna Publishers, Third Edition 2003
3. PhilipT.Krein, Elements of Power Electronics, Oxford University Press, 2013.
4. P.C.Sen, Power Electronics, Tata McGraw-Hill, 30th reprint, 2008.

Mapping COs and POs:

COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	2	2	-	2	-	-	2	2	1	-	1	2	3	2	1
CO2	3	2	2	1	2	-	-	2	2	1	-	1	2	3	2	1
CO3	3	2	2	1	2	1	-	2	2	1	-	1	2	3	2	1
CO4	3	2	2	-	2	1	-	2	2	1	-	1	2	3	2	1
CO5	3	2	2	-	2	1	-	2	2	1	-	1	2	3	2	1
Avg	3	2	2	1	2	1	-	2	2	1	-	1	2	3	2	1

UC23E01 ENGINEERING ENTREPRENEURSHIP DEVELOPMENT

L	T	P	C
2	0	2	3

COURSE OBJECTIVES:

1. Learn basic concepts in entrepreneurship, develop mind-set and skills necessary to explore entrepreneurship
2. Apply process of problem - opportunity identification and validation through human centred approach to design thinking in building solutions as part of engineering projects
3. Analyse market types, conduct market estimation, identify customers, create customer persona, develop the skills to create a compelling value proposition and build a Minimum Viable Product
4. Explore business models, create business plan, conduct financial analysis and feasibility analysis to assess the financial viability of a venture ideas & solutions built with domain expertise
5. Prepare and present an investible pitch deck of their practice venture to attract stakeholders

MODULE – I: ENTREPRENEURIAL MINDSET **4L,8P**

Introduction to Entrepreneurship: Definition – Types of Entrepreneurs – Emerging Economies – Developing and Understanding an Entrepreneurial Mindset – Importance of Technology Entrepreneurship – Benefits to the Society.

Case Analysis: Study cases of successful & failed engineering entrepreneurs - Foster Creative Thinking: Engage in a series of Problem-Identification and Problem-Solving tasks

MODULE – II: OPPORTUNITIES **4L,8P**

Problems and Opportunities – Ideas and Opportunities – Identifying problems in society – Creation of opportunities – Exploring Market Types – Estimating the Market Size, - Knowing the Customer and Consumer - Customer Segmentation - Identifying niche markets – Customer discovery and validation; Market research techniques, tools for validation of ideas and opportunities

Activity Session: Identify emerging sectors / potential opportunities in existing markets - Customer Interviews: Conduct preliminary interviews with potential customers for Opportunity Validation - Analyse feedback to refine the opportunity.

MODULE – III: PROTOTYPING & ITERATION **4L,8P**

Prototyping – Importance in entrepreneurial process – Types of Prototypes - Different methods – Tools & Techniques.

Hands-on sessions on prototyping tools (3D printing, electronics, software), Develop a prototype based on identified opportunities; Receive feedback and iterate on the prototypes.

MODULE – IV: BUSINESS MODELS & PITCHING **4L,8P**

Business Model and Types - Lean Approach - 9 block Lean Canvas Model - Riskiest Assumptions in Business Model Design – Using Business Model Canvas as a Tool – Pitching Techniques: Importance of pitching - Types of pitches - crafting a compelling pitch – pitch presentation skills - using storytelling to gain investor/customer attention.

Activity Session: Develop a business model canvas for the prototype; present and receive feedback from peers and mentors - Prepare and practice pitching the business ideas- Participate in a Pitching Competition and present to a panel of judges - receive & reflect feedback

MODULE – V: ENTREPRENEURIAL ECOSYSTEM **4L,8P**

Understanding the Entrepreneurial Ecosystem – Components: Angels, Venture Capitalists, Maker Spaces, Incubators, Accelerators, Investors. Financing models – equity, debt, crowdfunding, etc, Support from the government and corporates. Navigating Ecosystem Support: Searching & Identifying the Right Ecosystem Partner – Leveraging the Ecosystem - Building the right stakeholder network

Activity Session: Arrangement of Guest Speaker Sessions by successful entrepreneurs and entrepreneurial ecosystem leaders (incubation managers; angels; etc), Visit one or two entrepreneurial ecosystem players (Travel and visit a research park or incubator or makerspace or interact with startup founders).

TOTAL: 60 PERIODS

COURSE OUTCOMES:

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

CO1: Develop an Entrepreneurial Mind-set and Understand the Entrepreneurial Ecosystem Components and Funding types

CO2: Comprehend the process of opportunity identification through design thinking, identify market potential and customers

CO3: Generate and develop creative ideas through ideation techniques

CO4: Create prototypes to materialize design concepts and conduct testing to gather feedback and refine prototypes to build a validated MVP

CO5: Analyse and refine business models to ensure sustainability and profitability Prepare and deliver an investible pitch deck of their practice venture to attract stakeholders

REFERENCES:

1. Robert D. Hisrich, Michael P. Peters, Dean A. Shepherd, Sabyasachi Sinha (2020). Entrepreneurship, McGrawHill, 11th Edition
2. Bill Aulet (2024). Disciplined Entrepreneurship: 24 Steps to a Successful Startup. John Wiley & Sons.
3. Bill Aulet (2017). Disciplined Entrepreneurship Workbook. John Wiley & Sons.
4. Ries, E. (2011). The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses. Crown Business
5. Blank, S. G., & Dorf, B. (2012). The Startup Owner's Manual: The Step-by-Step Guide for Building a Great Company. K&S Ranch
6. Osterwalder, A., & Pigneur, Y. (2010). Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers. John Wiley & Sons
7. Marc Gruber & Sharon Tal (2019). Where to Play: 3 Steps for Discovering Your Most Valuable Market Opportunities. Pearson.

EE23505 **ELECTRICAL MACHINES LABORATORY – II** **L T P C**
0 0 4 2

LIST OF EXPERIMENTS

1. Predetermination of regulation of three-phase alternator using EMF, MMF and Potier triangle methods
2. Slip test and determination of X_d and X_q.
3. Study of starters of three-phase induction motors
4. No-load and blocked rotor tests and predetermination of performance of three-phase induction motor.
5. Load test on three phase induction motor.
6. V-curves and inverted V-curves of synchronous motor.
7. No-load and blocked rotor tests and predetermination of performance of single phase induction motor.
8. Load test on single phase induction motor.
9. Load test on synchronous induction motor.
10. Self and Separately excited operations of induction generator.
11. Performance Characteristics of permanent magnet synchronous machines.
12. Performance Characteristics of BLDC machines

TOTAL: 60 PERIODS

COURSE OUTCOMES:

After completion the above subject, students will be able to

- **CO1** find the performance characteristics of AC machines using direct and indirect methods.
- **CO2** compute the regulation of three phase alternator using the predetermination methods.
- **CO3** study the saliency nature of synchronous machine.
- **CO4** check the performance of single-phase induction motor.
- **CO5** study the starting and speed control of AC machines.

Mapping COs and POs:

COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	-	-	3	-	-	-	-	-	-	-	-	1	2	-	3
CO2	3	-	3	3	-	-	-	-	-	-	-	-	1	2	3	3
CO3	3	3	2	1	2	-	-	-	-	-	-	-	2	3	2	1
CO4	3	3	2	2	3	-	-	-	-	-	-	-	1	3	2	2
CO5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Avg	3	3	2.3	2.25	2.5	-	-	-	-	-	-	-	1.25	2.5	2.3	2.25

EE23601 POWER SYSTEM OPERATION AND CONTROL L T P C
3 0 2 4

UNIT I INTRODUCTION 9L,6P

Power scenario in Indian grid — National and Regional load dispatching centers — requirements of good power system - necessity of voltage and frequency regulation. System load variation, load curves - load forecast. Fundamentals of electricity markets: Deregulation, Types of electricity markets, Electricity market developments in India. IT application in electricity markets.

PRACTICALS

Simulation / Development of source code for

1. Load forecasting using curve fitting techniques
2. Determination of MCP in deregulated power system

UNIT II REAL POWER - FREQUENCY CONTROL 9L,6P

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

PRACTICALS

Simulation / Development of source code for

1. Load Frequency Control of single area system
2. Load Frequency Control of Two area system

UNIT III REACTIVE POWER – VOLTAGE CONTROL 9L,6P

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

PRACTICALS

Simulation / Development of source code for

1. Stability analysis of AVR
2. Sizing of SVC/STATCOM for voltage control of a HVAC bus

UNIT IV ECONOMIC OPERATION OF POWER SYSTEM 9L,6P

Statement of economic dispatch problem - input and output characteristics of thermal plant incremental cost curve - optimal operation of thermal units without and with transmission losses (no derivation of transmission loss coefficients) - lambda-iteration method - base point and participation factors method. Statement of Unit Commitment (UC) problem - constraints on UC problem - solution of UC problem using priority list - special aspects of short term and long term hydrothermal scheduling problems.

PRACTICALS

Simulation / Development of source code for

1. Economic Dispatch problem
2. Unit Commitment problem

UNIT V COMPUTER CONTROL OF POWER SYSTEM 9L,6P

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

PRACTICALS

Simulation / Development of source code for

1. State estimation using weighted least square estimation technique
2. Energy management in power system

TOTAL: 45l + 30 P= 75 PERIODS

COURSE OUTCOMES:

After completion the above subject, students will be able to

CO1 Analyze the day-to-day operation of electric power system.

CO2 Analyze the control actions that are implemented to meet the minute-to-minute variation of system real power demand.

CO3 Analyze the compensators for reactive power control.

CO4 Prepare day ahead and real time economic generation scheduling.

CO5 Understand computer control of power system and the role of IT for efficient Energy Management system.

TEXT BOOKS:

1. Olle.I.Elgerd, 'Electric Energy Systems theory - An introduction', McGraw Hill Education Pvt.Ltd., New Delhi, 34th reprint, 2010.
2. Allen. J. Wood and Bruce F. Wollen Berg, 'Power Generation, Operation and Control', JohnWiley & Sons, Inc., 2016.

REFERENCES:

1. Robert Miller and James Malinowski, 'Power system Opeartion', McGraw Hill Education Pvt. Ltd., New Delhi, 2009.
2. Kothari D.P. and Nagrath I.J., 'Power System Engineering', Tata mcgraw-Hill Education,Second Edition, 2008.
3. Hadi Saadat, 'Power System Analysis', McGraw Hill Education Pvt. Ltd., New Delhi, 21streprint, 2010.
4. Kundur P., 'Power System Stability and Control, McGraw Hill Education Pvt. Ltd., New Delhi,10th reprint, 2010.
5. Mohammad Shahidehpour, Muwaffaq Alomoush, Marcel Dekker, "Restructured Electrical power systems: operation, trading and volatility" Pub., 2001.

Mapping COs and POs:																
COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	1	2	1	1	-	-	-	1	-	-	1	3	-	1	-
CO2	3	1	2	1	1	-	-	-	1	-	-	1	3	-	1	-
CO3	3	1	2	1	1	-	-	-	1	-	-	1	3	-	1	-
CO4	3	1	2	1	1	-	-	-	1	-	-	1	3	-	1	-
CO5	3	1	2	1	1	-	-	-	1	-	-	1	3	-	1	-
Avg	3	1	2	1	1	-	-	-	1	-	-	1	3	-	1	-

EE23602 **PROTECTION AND SWITCHGEAR** **L T P C**
3 0 2 4

UNIT I FAULTS AND PROTECTIVE SCHEMES 9L,6P

Nature, causes and consequence of faults – fault statistics, types of faults (symmetrical and unsymmetrical) – fault current calculation, Reactors— need for protective schemes-CT, PT, Buchholz relay -zones of protection and essential qualities of protection.

PRACTICALS

1. Simulation of unsymmetrical and symmetrical faults

UNIT II ELECTROMAGNETIC RELAYS 9L, 12P

Basic requirements of protective relaying – Classification and Operating principles of relays- Electromagnetic Relays – Over current, Directional, Distance, Differential and Negative sequence relays, R-X diagram – Universal Torque equation.

PRACTICALS

1. Comparison of distance relays using simulation methods
2. Study of overvoltage relay and simulation with one application

UNIT III APPARATUS PROTECTION 9L, 6P

Application of instrument transformers in protection schemes – Protection of transformer, generator, motor, bus bars, feeders and transmission line.

PRACTICALS

1. Protection of generator using Merz Price circulating current scheme

UNIT IV STATIC RELAYS AND NUMERICAL PROTECTION 9L, 6P

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

PRACTICALS

1. Overcurrent protection of transformer

UNIT V CIRCUIT BREAKERS 9L

Physics of arcing phenomenon and arc interruption - DC and AC circuit breaking – re-striking voltage and recovery voltage - RRRV - current chopping - interruption of capacitive and inductive currents, resistance switching- Types of circuit breakers – air, oil, SF6 and vacuum circuit breakers – comparison of different circuit breakers – Rating and selection of Circuit breakers.

TOTAL: 45L + 30 P = 75 PERIODS

COURSE OUTCOMES:

After completion the above subject, students will be able to

CO1 analyse different types of faults and their effects on power system and understand the practical significance of protection zones.

CO2 understand the basic principles, construction and characteristics of different Electromagnetic relays.

CO3 protect different power equipment like transformer, generator etc., against various electrical faults.

CO4 understand different aspects of static relays and numerical protection schemes.

CO5 understand the principles, construction, selection and problems associated with Different types of circuit breaker.

TEXT BOOKS:

1. Sunil S.Rao, Switchgear and Protection, Khanna publishers, New Delhi, 2008. Switchgear Protection and Power Systems (Theory, Practice & Solved Problems)
2. Y.G.Paithankar and S.R.Bhide, Fundamentals of power system protection, Second Edition, Prentice Hall of India Pvt. Ltd., New Delhi – 2010

REFERENCES:

1. BadriRam ,B.H.Vishwakarma, Power System Protection and Switchgear, New AgeInternational Pvt Ltd Publishers, Second Edition 2011.
2. B.Rabindranath and N.Chander, Power System Protection and Switchgear, New AgeInternational (P) Ltd., First Edition 2011.
3. M.L.Soni, P.V.Gupta, U.S.Bhatnagar, A.Chakrabarti, A Text Book on Power SystemEngineering, Dhanpat Rai & Co., 1998.
4. C.L.Wadhwa, Electrical Power Systems, 6th Edition, New Age International (P) Ltd.,2010.
5. RavindraP.Singh, “Switchgear and Power System Protection “ PHI Learning PrivateLtd., New Delhi 2009

Mapping COs and POs:

COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	3	-	-	2	-	-	-	-	-	-	-	3	3	2	2
CO2	3	3	-	-	-	-	-	-	-	-	-	-	3	3	2	2
CO3	3	3	2	2	2	-	2	-	-	-	-	-	3	3	2	2
CO4	3	3	2	2	2	-	2	-	-	-	1	-	3	3	2	2
CO5	3	3	2	2	-	-	-	-	-	-	1	-	3	3	2	2
Avg	3	3	2	2	2	-	2	-	-	-	1	-	3	3	2	2

EE23U02	SUSTAINABLE DEVELOPMENT– ELECTRICAL ENGINEERING	L	T	P	C
		2	0	2	3

UNIT I INTRODUCTION 6

Principles & Historical perspectives, Importance and need for sustainability in engineering and technology, impact and implications. United Nations Sustainability Development Goals (SDG), UN summit – Rio & outcome, Sustainability and development indicators.

UNIT II ENVIRONMENTAL SUSTAINABILITY 6

Climate change, Biodiversity loss, Pollution and waste management, Renewable vs. non-renewable resources, Water and energy conservation, Sustainable agriculture and forestry. National and international policies, Environmental regulations and compliance, Ecological Footprint Analysis.

UNIT III SOCIAL & ECONOMIC SUSTAINABILITY 9

Equity and justice, Community development, Smart cities and sustainable infrastructure, Cultural heritage and sustainability, Ethical considerations in sustainable development.

Triple bottom line approach, Sustainable economic growth, Corporate social responsibility (CSR), Green marketing and sustainable product design, Circular economy and waste minimization,Green accounting and sustainability reporting.

UNIT IV SUSTAINABLE ELECTRICAL ENGINEERING 9

Energy Efficiency, Environmental Impact, Sustainable Technology, Renewable Energy Integration, Societal and Ecological Assessments in Electrical Engineering.

UNIT V SUSTAINABILITY PRACTICES 30

- Energy audits in households/laboratories
- Implementation of power factor correction and harmonic filtering
- Design of small-scale solar water heating systems
- Simulation study : off grid and grid tied Solar PV.
- Energy performance simulation of buildings
- Renewable energy system modeling and analysis
- Microgrid and nanogrid design and simulation
- Ecological footprint assessment and SDG analysis
- Electric vehicle charging station design and feasibility study
- Performance Assessment of ICE and EV
- Life cycle assessment case study of EV battery.

TOTAL:60 PERIODS

REFERENCES:

1. Allen, D., &Shonnard, D. R. (2011). Sustainable engineering: Concepts, design and case studies. Prentice Hall.
2. Munier, N. (2005). Introduction to sustainability (pp. 3558-6). Amsterdam, The Netherlands: Springer.
3. Blackburn, W. R. (2012). The sustainability handbook: The complete management guide to achieving social, economic and environmental responsibility. Routledge.
4. Clini, C., Musu, I., &Gullino, M. L. (2008). Sustainable development and environmental management. Published by Springer, PO Box, 17, 3300.
5. Bennett, M., James, P., &Klinkers, L. (Eds.). (2017). Sustainable measures: Evaluation and reporting of environmental and social performance. Routledge.

6. Seliger, G. (2012). Sustainable manufacturing for global value creation (pp. 3-8). Springer Berlin Heidelberg.
7. Stark, R., Seliger, G., & Bonvoisin, J. (2017). Sustainable manufacturing: Challenges, solutions and implementation perspectives. Springer Nature.
8. Davim, J. P. (Ed.). (2013). Sustainable manufacturing. John Wiley & Sons.
9. Down, R. D., & Lehr, J. H. (Eds.). (2005). Environmental instrumentation and analysis handbook. John Wiley & Sons.
10. Borlase, S. (Ed.). (2012). Smart grids: infrastructure, technology, and solutions. CRC press.
11. Roslan, M. F., Hannan, M. A., Ker, P. J., & Uddin, M. N. (2019). Microgrid control methods toward achieving sustainable energy management. Applied Energy, 240, 583-607.
12. Mulder, K. (Ed.). (2017). Sustainable development for engineers: A handbook and resource guide. Routledge.

SEMESTER VII

EE23701 HIGH VOLTAGE ENGINEERING L T P C
3 0 2 4

UNIT I OVER VOLTAGES IN ELECTRICAL POWER SYSTEMS 9L

Causes of over voltages and its effects on power system – Lightning, switching surges and temporary over voltages – Reflection and Refractionof Travelling waves- protection against over voltages- Insulation Coordination.

UNIT II DIELECTRIC BREAKDOWN 9L,9P

Properties of Dielectric materials - Gaseous breakdown in uniform and non-uniform fields –Corona discharges – Vacuum breakdown – Conduction and breakdown in pure and commercial liquids,– Breakdown mechanisms in solid and composite dielectrics- Applications of insulating materials in electrical equipment.

PRACTICALS

1. Breakdown study of Gaseous dielectrics under Uniform and Non-uniform field
2. Breakdown study of Liquid dielectrics under Uniform and Non-uniform field
3. Breakdown study of Solid dielectrics under uniform field

UNIT III GENERATION AND MEASUREMENTS OF HIGH VOLTAGESAND HIGH CURRENTS 9L, 9P

Generation of High DC, AC, impulse voltages and impulse currents - Analysisof DC/AC and Impulse generator circuits - Tripping and control of impulse generators**,** Measurement of High voltages - High Resistance with series ammeter – Dividers - Resistance, Capacitance and Mixed dividers - Peak Voltmeter, Generating Voltmeters, Electrostatic Voltmeters – Sphere Gaps, Digital techniques in high voltage measurement, High current measurements – High current shunts, Rogowski coils and magnetic links.

PRACTICALS

1.Design and Analysis of High voltage generation using Circuit simulation packages.
- Impulse Generator
- HVDC Generator

2. Generation and Measurement of High AC voltage
3. Generation and Measurement of High DC voltage
4. Generation and Measurement of High Impulse voltage

UNIT IV HIGH VOLTAGE TESTING 9L, 12P

High voltage testing of electrical power apparatus- International and Indian standards – Power frequency, impulse voltage and DC testing of Insulators, circuit breakers, bushing, isolators, cables and transformers.

PRACTICALS

1. Power Frequency voltage withstand test on High voltage power apparatus
2. Impulse voltage withstand test on High voltage power apparatus

UNIT V HIGH VOLTAGE APPLICATIONS IN INDUSTRY 9L

Introduction – electrostatic applications- electrostatic precipitation, separation, painting / coating, spraying, imaging, printing, Transport of materials – manufacturing of sand paper – Smoke particle detector – Electrostatic spinning, pumping, propulsion – Ozone generation – Biomedical applications.

TOTAL: 45 L+ 30 P = 75 PERIODS

COURSE OUTCOMES:

After completion of the above subject, students will be able to

CO1 analyze various over voltages and its effects on power systems.

CO2 understand the breakdown phenomena in different dielectric medium under uniform and non-uniform fields.

CO3 explain the methods of generating and measuring High DC, AC, Impulse voltage and currents.

CO4 suggest and Conduct suitable HV testing of Electrical power apparatus as per Standards.

CO5 explain the Industrial Applications of High Voltage Engineering.

TEXT BOOKS

1. M.S.Naidu and V. Kamaraju, 'High Voltage Engineering', Tata McGraw Hill, Sixth Edition,2020.
2. E. Kuffel and W.S. Zaengl, J.Kuffel, 'High voltage Engineering fundamentals',NewnessSecond Edition, Elsevier , New Delhi, 2005.
3. C.L. Wadhwa, 'High voltage Engineering', New Age International Publishers, FourthEdition,2020.

REFERENCES

1. L.L.Alston, High Voltage Technology, Oxford University Press, First Indian Edition2006.
2. Mazen Abdel – Salam, Hussein Anis, Ahdab A-Morshedy, RoshdayRadwan, High VoltageEngineering – Theory &Practice,Second Edition, Taylor & FrancisGourp, 2019
3. Subir Ray." An Introduction to High Voltage Engineering "PHI Learning Private Limited,New Delhi, Second Edition-2011

Mapping COs and POs:

COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	2	3	2	2	3	2	2	-	1	2	2	3	2	2	1
CO2	3	2	2	2	2	1	2	3	1	1	1	2	2	2	2	2
CO3	3	3	2	3	2	1	2	2	2	1	1	1	3	2	1	2
CO4	3	2	2	3	2	2	3	3	3	2	3	2	2	3	2	2
CO5	3	2	3	2	3	3	3	3	2	2	3	3	2	3	3	3
Avg	3	2.2	2.4	2.4	2.2	2	2.4	2.6	1.6	1.4	2	2	2.4	2.4	2	2

EE23U01	STANDARDS - ELECTRICAL ENGINEERING	L	T	P	C
		1	0	0	1

MODULE I OVERVIEW OF STANDARDS **6**

Basic concepts of standardization; Purpose of Standardization, marking and certification of articles and processes; Importance of standards to industry, policy makers, trade, sustainability and innovation. Objectives, roles and functions of BIS, Bureau of Indian Standards Act, ISO/IEC Directives; WTO Good Practices for Standardization. Important Indian and International Standards.

MODULE II ELECTRICAL INSTALLATION IN BUILDING **9**

IS 18732 : 2023-Layout - Planning and Design- IS/IEC 61936 (Part 1) - Installation of Equipment-Safety Services-2023 National Electrical Code -Typical Distribution System- Electrical Installations in Industrial Buildings and Agricultural Premises-Hazardous Areas- IS 1646: 2002-General Requirements - Transformer Substation- IS3043- Earthing practices- IS732- 2019 Code of Practice for Wiring Methods-Special Electrical Equipment and Locations and Testing-Portable Fire Extinguishers-IS 15683 - Classification of Extinguishers- Construction Requirement-Tests.

TOTAL:15 PERIODS

COURSE OUTCOMES:

On Completion of This Course, The Student Is anticipated to be able to:

CO1	Describe the General Aims and Principles of Standardization with Functions of Standardization Set up In BIS
CO2	Acquire Good Practices for the Selection of Electrical Equipment Forming Part of An Electrical Installation
CO3	Realize the Practice of NEC for Installations
CO4	Understand the General Safety Procedures and Practices In Electrical Work
CO5	Attain Basic Knowledge on Various Types of Fire Protections

TEXT BOOKS:

1. Is 18732 : 2023 Guide For Implementation Of Electrical Installation Standards In Buildings
2. Is 1646: 2022 Fire Safety Of Buildings (General): Electrical Installations
3. Indian Standard Portable Fire Extinguishers — Performance And Construction — Specification (First Revision) Is 15683 : 2018
4. 2023 National Electrical Code (Nec®)

REFERENCES:

1. Https://Www.Bis.Gov.In/
2. The CEA Regulations and The Electricity Act, 2003 Rules

EMERGING TECHNOLOGY COURSES

EE23E01	AI AND ML FUNDAMENTALS	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES:

- Understand the basics of AI and search mechanisms.
- Learn the basics of reasoning technqiues.
- Know the basics of Machine learning
- Know the concepts of classification
- Understand the basics of clustering and reinforcement algorithms.

UNIT I	UNINFORMED AND INFORMED SEARCHES	9L, 6P

AI – Foundations and History of AI - The Intelligent Agent - Problem-Solving by Search – Uninformed Search – Informed Heuristic Searches - Greedy – A* Search case Study – Power grid as a graph and pathfinding, Finding the optimal routing path for electrical traces on a printed circuit board (PCB).

PRACTICALS:

1. Search implementation on BFS and DFS with computational complexity
2. Search implementation on Greedy and A* algorithm

Suggested Activities:

- Discussion on history of AI
- Tutorial on the need for AI for Electrical Engineering
- Tutorial on search problems

Suggested Evaluation Methods:

- Quizz on history of AI
- Assignment of problem solving in AI

UNIT II	SEARCH TECHNIQUES AND REASONING METHODS	9L, 6P

Constraint Satisfaction Problems - Logical Agent – Proposition Logic – Syntax and Semantics – Theorem Proving – Model Checking – Inference in First Order Logic: Forward Chaining – Backward Chaining – Resolution.

PRACTICALS:

1. Implementation of Constraint Satisfaction Problem.
2. Programming exercises on inference using Proposition logic.
3. Programming exercises on inference using First Order Logic

Suggested Activities:

- Discussion on first order logic
- Flipped classroom on reasoning techniques

Suggested Evaluation Methods:

- Assignment of solving constraint problems
- Quizz on reasoning

UNIT III	INTRODUCTION TO MACHINE LEARNING	9L, 6P

Basic Concepts in Machine Learning – Types of Machine Learning – Supervised, Unsupervised, Semi-supervised and Reinforcement Learning - Applications of Machine Learning - Basics of Learning Theory – Concept Learning – Challenges of Machine Learning – Feature Engineering - Linear Regression – Single and Multiple Variable Regression – Polynomial Regression – Bias and variance - Logistic regression – Case studies - Predicting future electrical load demand based on historical data, Fault Prediction in Power Systems.

PRACTICALS:

1. Exploratory data analysis
2. Learning of Jupyter Notebook and Google Colab Environment
3. Learning Python packages like Scikit learn for machine Learning
4. Develop an application that makes predictions from Boston Housing Data using Linear Regression.
5. Construct a student dataset with marks. Develop an application that makes predictions from data using Logistic Regression for pass or fail.

Suggested Activities:

- Installation of a programming environment for machine learning.
- Tutorial on Anaconda and colab environment
- Flipped classrom for regression problems for electrical engineering.

Suggested Evaluation Methods:

- Assignment of regression problems.
- Quizz on python tools for machine learning

UNIT IV	INTRODUCTION TO CLASSIFICATION AND NEURAL NETWORKS	9L, 6P

Instance-based Learning - K-Nearest Neighbor - Decision Tree – ID3 Tree construction – Entropy – Validation of Decision Trees- Model Evaluation Methods – Basics of Neural Networks – Biological and Artificial Neurons - Perceptron – Perceptron Rule - Feedforward networks – backpropagation Algorithms – Classification using Neural networks – Challenges in ANN – SVM Classification – case Studies - Identifying and classifying different types of faults in electrical systems, Predicting the type of load (residential, commercial, industrial) based on historical consumption data, Fault Detection in Power Systems.

PRACTICALS:

1. Implement a classifier using ID3 algorithms.
2. Develop a system to implement a classifier using SVM.
3. Create a simple neural network for classification of Tabular data.

Suggested Activities:

- Discussion on classification problems.
- Group discussion about the need for classification in electrical engineering

Suggested Evaluation Methods:

- Assignment of classification algorithms.
- Demonstration of numerical skills in solving real world problems.
- Quizz

UNIT V	UNSUPERVISED LEARNING	9L, 6P

Introduction to Clustering - Hierarchical Clustering – Single Linkage – Complete Linkage – Average Linkage – Partitional Clustering Algorithms – K-means - Expectation Maximization Algorithm – Linear Discriminant Analysis – Principal Component Analysis - Latest Trends – Overview and Scope of Reinforcement Learning – Components of reinforcement Learning – Model-based and Model-free models – Q-Learning Algorithm – Case Studies - Customer Segmentation in Power Consumption, Identifying and grouping similar types of faults in electrical systems.

PRACTICALS:

1. Develop a system for implementing single, average, and complete linkage algorithms.
2. Develop a system that automatically groups articles by similarity using K-means clustering.

Suggested Activities:

- Discussion on reinforcement learning.
- Gropu discussion of clustering in electrical engineering.

Suggested Evaluation Methods:

- Assignment of clustering problems. .
- Demonstration of numerical skills in solving clustering problems.
- Quizz

TOTAL: 45L + 15P = 75 PERIODS

COURSE OUTCOMES:

Upon successful completion of the course, the student will be able to:

CO 1.	Understand and apply search strategies for real-time problems.
CO 2.	Apply reasoning techniques to real-world problems.
CO 3.	Know the basics of machine learning.
CO 4.	Know about the basics of Classification using ML algorithms.
CO 5.	Understand and apply Clustering algorithms.

TEXT BOOKS:

1. Stuart J. Russell, Peter Norvig, “Artificial Intelligence - A Modern Approach”, Fourth Edition, Pearson Publishers, 2021.
2. Tom Mitchell, “Machine Learning”, McGraw-Hill, 1997.
3. Sridhar S, Vijayalakshmi M, “Machine Learning”, First Edition, Oxford University Press, 2022.
4. Applications of Artificial Intelligence and Machine Learning- Select proceedings of ICAAAIML, Lecture notes in Electrical Engineering – Ankur Choudhary et al. Springer, 2020.

REFERENCES:

1. Dheepak Khemani, “A first course in Artificial Intelligence”, McGraw Hill Education Pvt Ltd., New Delhi, 2013.
2. Elaine Rich, Kevin Knight, Shivashankar B. Nair, “Artificial Intelligence”, Third Edition, Tata McGraw-Hill Education, 2008.

3. Introduction to Statistics, Lumen Learning Courseware, https://courses.lumenlearning.com/introstats1/, Open Education Resource
4. Christopher Bishop, “Pattern Recognition and Machine Learning”, First Edition, Springer, 2006.

CO-PO & PSO MAPPING

CO	Program Outcomes (POs) & Program Specific Outcomes (PSOs)														
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	3	3	3	2	2	2	-	2	2	2	2	3	3	3
CO2	3	3	3	3	2	2	2	-	2	2	2	2	3	3	3
CO3	3	3	3	3	2	2	2	-	2	2	2	2	3	3	3
CO4	3	3	3	3	2	2	2	-	2	2	2	2	3	3	3
CO5	3	3	3	3	2	2	2	-	2	2	2	2	3	3	3
CO6	3	3	3	3	3	2	2	-	2	2	2	2	3	3	3

1-low, 2-medium, 3-high, ‘-“- no correlation

EE23E02 **ELECTRICAL MACHINE DESIGN FOR EV** **L T P C**
3 0 2 4

UNIT I DESIGN OF FIELD SYSTEM AND ARMATURE 9L, 6P

Major considerations in Electrical Machine Design – Materials for Electrical apparatus – Design of Magnetic circuits – Magnetising current – Calculation of MMF Leakage in Armature. Design of lap winding and wave winding- Introduction to Computer aided design - Design of permanent magnets.

PRACTICALS

1. Design of field system
2. Design of solenoid, relay
3. Design of Field Windings / permanent magnets of DC machine

UNIT II DESIGN OF TRANSFORMERS 9L, 6P

Construction - KVA output for single and three phase transformers – Overall dimensions – design of yoke, core and winding for core and shell type transformers – Estimation of No load current – Temperature rise in Transformers – Design of Tank and cooling tubes of Transformers. Computer program: Complete Design of single phase core transformer - Design of high frequency transformers for wireless charging in EV applications.

PRACTICALS

1. Complete design of a transformer and performance evaluation calculation for power frequency and high frequency applications

UNIT III DESIGN OF DC MACHINES 9L, 6P

Construction - Output Equation – Main Dimensions – Choice of specific loadings – Selection of number of poles – Design of Armature – Design of commutator and brushes – Design of field- Computer program: Design of Armature main dimensions, Design of Permanent Magnet DC motors for EV applications.

PRACTICALS

1 Design of armature winding of DC machine
2 Complete design of DC machine and performance evaluation calculation

UNIT IV DESIGN OF INDUCTION MOTORS 9L, 6P

Construction - Output equation of Induction motor – Main dimensions – choice of specific loadings – Design of squirrel cage rotor and wound rotor – Operating characteristics- Magnetizing current - Short circuit current – Circle diagram Computer program:Design of slip-ring rotor, Design of induction motors for EV applications.

PRACTICALS

1 Stator design of AC machines
2 Rotor design of Induction motor
3 Complete design of a induction motor and performance evaluation calculation

UNIT V DESIGN OF SYNCHRONOUS MACHINES 9L, 6P

Output equation – choice of specific loadings – Design of salient pole machines – Short circuit ratio – Armature design – Estimation of air gap length – Design of rotor – Determination of full load field mmf – Design of field winding – Design of turbo alternators Computer program: Design of Stator main dimensions - Design of PMSM and Brushless DC Machines for EV applications.

PRACTICALS

1 Complete design of a synchronous machine and performance evaluation calculation
2 Complete design of PMSM and BLDC machines.

TOTAL: 45L+30P = 75 PERIODS

COURSE OUTCOMES:

After completion the above subject, students will be able to

CO1 Understand basics of design considerations for rotating and static electrical machines.
CO2 Design of single and three phase transformer for power / high frequency applications.
CO3 Design of armature and field of DC machines for applications inlcuding EV Technology
CO4 Design of stator and rotor of induction motor and analyse its performance for applications inlcuding EV Technology
CO5 Design and analyze the performance of synchronous / PMSM / BLDC machines for applications inlcuding EV Technology

TEXT BOOKS

1 Sawhney, A.K., 'A Course in Electrical Machine Design', Dhanpat Rai & Sons, New Delhi, Fifth Edition, 1984.
2 M V Deshpande 'Design and Testing of Electrical Machines' PHI learning Pvt Ltd, 2011
3 Sen, S.K., 'Principles of Electrical Machine Designs with Computer Programmes', Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, Second Edition, 2009.

REFERENCES:

1 A.Shanmugasundaram, G.Gangadharan, R.Palani 'Electrical Machine Design Data Book',New Age International Pvt. Ltd., Reprint 2007.
2 Electrical Machine Design', Balbir Singh, Vikas Publishing House Private Limited, 1981
3 K.M.Vishnumurthy 'Computer aided design of electrical machines' B S Publications, 2008
4 Iqbal Hussain, "Electric and Hybrid Vehicles: Design Fundamentals, Second Edition" CRC Press, Taylor & Francis Group, Third Edition 2021.

Mapping COs and POs:

COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
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CO2	3	2	-	1	1	-	-	-	-	-	-	-	3		-	-
CO3	2	2	3	1	1	-	-	-	-	-	2	3	3	2	-	-
CO4	1	2	3	1	1	-	-	1	1	-		3	3	2	-	-
CO5	2	2	1	-	1	2	-	-	-	-	2	-	3		2	-
Avg	2	2	2.33	1	1	2	-	1	1	-	2	3	3	2	2	-

EE23E03	SUSTAINABLE ELECTRIFICATION FOR REMOTE COMMUNITIES	L	T	P	C
		3	0	2	4

UNIT I FUNDAMENTALS OF NANO AND MICRO GRIDS 9

Need for nano and micro grids in remote areas- Architectures: Comparison of nano & micro grid architectures -Distributed Generation (DG) technologies for renewable energy sources -Techno-economic feasibility analysis.

UNIT II DESIGN CONSIDERATIONS FOR NANO GRIDS 9

Renewable energy source selection for nano grids-design , sizing of DG units, converters, storage for nano grid- Control strategies and Protection schemes for nano grids.

UNIT III DESIGN CONSIDERATIONS FOR MICRO GRIDS 9

Resource assessment - Design principles and considerations for micro grids in remote areas-Integration of renewable energy sources into micro grids - Power converters- Energy storage selection and integration for microgrids.

UNIT IV CONTROL AND PROTECTION FOR MICRO GRIDS 9

Control strategies :centralized, decentralized, droop control, communication protocols- Power management : load shedding, demand response, islanding with seamless transition- Microgrid protection schemes :fault detection, isolation, reconfiguration-Communication infrastructure :SCADA systems, data acquisition for real-time management

UNIT V ADVANCED TOPICS IN REMOTE AREA ELECTRIFICATION 9

Hybrid nano and micro grid configurations - Integration of energy management systems - Microgrid resilience - Socio-economic and environmental impact assessment of nano and micro grids in remote communities.

TOTAL : 45 PERIODS

LAB COMPONENT 30

1. Design of a Nano Grid for Remote Hut
2. Modeling and Simulation of a Nano Grid with a Solar PV system
3. Performance Evaluation of a Power Converter in a Nano Grid System
4. Integration of Energy Storage with a Nano Grid Model
5. Design and Simulation of a Microgrid with Distributed Generation Units for Remote Community
6. Analysis of Islanding Protection in a Microgrid System
7. Implementation of Load Management Techniques for Microgrids
8. Advanced Microgrid Control Strategy Implementation in Simulation Software

Demonstration of a Microgrid Hardware Test Bed

COURSE OUTCOMES:

On Completion of This Course, The Student Is anticipated to be able to:

CO1	Understand Nano and Microgrid
CO2	Design and analyze Nanogrids for remote hut
CO3	Design and analyze Microgrids for remote communities
CO4	Understand Control and Protection for Microgrids
CO5	Analyze Socio-economic and environmental impacts of nano and micro grids

TEXT BOOKS:

1. Antonio Carlos Zambroni de Souza and Miguel Castilla, Microgrids: Design and Implementation, Springer, 2019.
2. Rajeev Kumar Chauhan, Kalpana Chauhan, Sri Niwas Singh , Microgrids for Rural Areas: Research and case studies (Energy Engineering), IET, 2020.
3. Nikos Hatziargyriou, Microgrids: Architectures and Control, John Wiley and Sons Ltd, 2014.

REFERENCES:

1. Simon Rolland, Rural Electrification with Renewable Energy Technologies, Quality Standars and Business Models, 2011.

Mapping COs and POs:																
COs	**Pos**												**PSOs**			
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**
CO1	1	2	2	2	-	2	2	-	-	1	1	1	2	3	1	1
CO2	1	2	2	2	-	2	2	-	-	1	1	1	2	3	1	1
CO3	1	2	2	2	-	2	2	-	-	1	1	1	2	3	1	1
CO4	1	2	2	2	-	2	2	-	-	1	1	1	2	3	1	1
CO5	1	2	2	2	-	2	2	-	-	1	1	1	2	3	1	1
Avg	1	2	2	2	-	2	2	-	-	1	1	1	2	3	1	1

EE23E04	EMBEDDED SYSTEM DESIGN	L	T	P	C
		3	0	2	4

UNIT I **INTRODUCTION TO EMBEDDED SYSTEMS** **9L,6P**

Introduction to Embedded Systems –Structural units in Embedded processor, selection of processor & memory devices- DMA —– Memory management methods- Timer and Counting devices, Real Time Clock, In-circuit emulator, Target Hardware Debugging.

PRACTICALS

Laboratory exercise:Use any Embedded processor/IDE/open source platform to givehands-on training on basic concepts of embedded system design:

1 Introduction to IDE and Programming Environment.

2 Configure timer block for signal generation (with given frequency).

UNIT II **EMBEDDED NETWORKING** **9L,6P**

Embedded Networking: Introduction, I/O Device Ports & Buses– Serial Bus communication protocols RS232 standard – RS485 – CAN Bus- Serial Peripheral Interface (SPI) – Inter-Integrated Circuits (I^2C).

PRACTICALS

Laboratory exercise:Use any Embedded processor/IDE/open source platform to givehands-on training on basic concepts of embedded system design:

1 I^2C communication with peripherals

2 Master-slave communication between processors using SPI.

UNIT III **INTERRUPTS SERVICE MECHANISM AND DEVICE DRIVER** **9L,6P**

Programmed-I/O busy-wait approach without interrupt service mechanism-ISR concept-interrupt sources – multiple interrupts – context and periods for context switching, interrupt latency and deadline — Introduction to Device Drivers.

PRACTICALS

Laboratory exercise:Use any Embedded processor/IDE/open source platform to givehands-on training on basic concepts of embedded system design:

1 Interrupts programming example using GPIO.

2 Networking of processor using Wi-Fi.

UNIT IV **RTOS-BASED EMBEDDED SYSTEM DESIGN** **9L,6P**

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

PRACTICALS

Laboratory exercise:Use any Embedded processor/IDE/open source platform to givehands-on training on basic concepts of embedded system design:

1 Basic RTOS concept and programming

2 Assignment: Introduction to VxWorks, ЧC/OS-II, RT Linux

UNIT V EMBEDDED SYSTEM APPLICATION DEVELOPMENT 9L,6P

Embedded Product Development Life Cycle - Case Study: Precision Agriculture- Autonomous car.

PRACTICALS

Laboratory exercise:Use any Embedded processor/IDE/open source platform to givehands-on training on basic concepts of embedded system design:

1 Embedded systems-based Mini project

TOTAL: 45L+30P=75 PERIODS

COURSE OUTCOMES:

CO1 The hardware functionals and software strategies required to develop various Embedded systems.
CO2 The basic differences between various Bus communication standards.
CO3 The incorporation of the interface as Interrupt services.
CO4 The various scheduling algorithms through a Real-time operating system.
CO5 The various embedded concepts for developing automation applications.

TEXT BOOKS:

1. Rajkamal, 'Embedded system-Architecture, Programming, Design, McGraw-Hill Edu, 3rd edition 2017
2. Peckol, "Embedded system Design", John Wiley & Sons,2010.

REFERENCES:

1. Shibu. K.V, "Introduction to Embedded Systems", TataMcgraw Hill, 2nd edition 2017.
2. Lya B.Das," Embedded Systems" ,Pearson Education, 1st edition 2012.
3. Parag H.Dave,Himanshu B.Dave," Embedded Systems-Concepts ,Design and Programming, Pearson Education,2015, 1st edition.
4. Elicia White, "Making Embedded systems", O'Reilly Series ,SPD,2011, 1st edition.
5. Jonathan W. Valvano, 'Embedded Microcomputer Systems Real-time Interfacing', Cengage Learning , 3rd edition 2010.
6. Tammy Noergaard, "Embedded Systems Architecture", Newnes, 2nd edition, 2013.

List of Open Source Software/ Learning websites:

1. https://nptel.ac.in/courses/108102045
2. https://ece.uwaterloo.ca/~dwharder/icsrts/Lecture materials/A_practical_introduction_to_re al-time_systems_for_undergraduate_engineering.pdf
3. https://www.circuitbasics.com/basics-of-the-i2c-communication-protocol/
4. https://www.tutorialspoint.com/embedded_systems/es_interrupts.htm
5. https://www.theengineeringprojects.com/2016/11/examples-of-embedded-systems.html#:~:text=Embedded%20

Product%3A%20Automatic%20Washing%20Machine, done%20by%20your%20machine%20itself.

MAPPING COS AND POS:																
COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	3	2	2	3	1	1	1	1	-	2	2	3	3	2	1
CO2	2	2	3	2	2	1	1	1	1	-	2	2	2	3	2	2
CO3	2	3	1	2	1	1	1	1	1	-	2	1	1	1	1	2
CO4	3	2	1	1	2	1	1	1	1	-	2	1	1	2	1	1
CO5	2	1	2	3	3	1	1	1	1	-	2	1	2	2	1	3
Avg	2.4	2.2	1.8	2	2.2	1	1	1	1	-	2	1.3	1.8	2.2	1.4	1.8

EE23E05	MEMS AND NEMS	L	T	P	C
		3	0	2	4

UNIT I INTRODUCTION TO MEMS AND NEMS 9

Overview of Micro electro mechanical systems and Nano Electro mechanical systems, devices andtechnologies, Laws of scaling- Materials for MEMS and NEMS - Applications of MEMS and NEMS.

UNIT II MICRO-MACHINING AND MICROFABRICATION TECHNIQUES 9

Photolithography- Micro manufacturing, Bulk micro machining, surface micro machining, LIGA.

UNIT III MICRO SENSORS AND MICRO ACTUATORS 9

Micromachining: Capactive Sensors- Piezoresistive Sensors- Piezoelectric actuators.

UNIT IV NEMS TECHNOLOGY 9

Atomic scale precision engineering- Nano Fabrication techniques – NEMS for sensors and actuators.

UNIT V MEMS and NEMS APPLICATION 9

Bio MEMS- Optical NEMS- Micro motors- Smart Sensors - Recent trends in MEMS and NEMS.

TOTAL 45

LAB COMPONENT 30

1. Physical Modeling of MOSFETs with Multi-Physics Tools
2. Design and Simulation of an Electrostatic Capacitive Sensor
3. Design and Simulation of a Micropiezoresitive Pressure Sensor
4. Design and Simulation of a Piezoelectric Actuator
5. Simulation Analysis of a MEMS Accelerometer
6. Modeling of Nano Devices
7. Assignment: Role of MEMS AND NEMS devices for Industry Standard 5.0.
8. Mini project :Design and analysis of any MEMS/NEMS device using multi physics tool

TOTAL: 75 PERIODS

COURSE OUTCOMES:

CO1 Explain the material properties and the significance of MEMS and NEMS for industrialautomation.

CO2 Demonstrate knowledge delivery on micromachining and micro fabrication.

CO3 Apply the fabrication mechanism for MEMS sensor and actuators.

CO4 Apply the concepts of MEMS and NEMS to models, simulate and process the sensors andactuators.

CO5 Improved Employability and entrepreneurship capacity due to knowledge up gradation onMEMS and NEMS technology.

TEXT BOOKS:

1. Chang Liu, “Foundations of MEMS”, Pearson International Edition, 2011, 2nd Edition.
2. Tai-.Ran Hsu, “MEMS and Microsystems: design , manufacture, and Nanoscale”- 2nd Edition,John Wiley & Sons, Inc., Hoboken, New Jersey, 2008.
3. Lyshevski, S.E. “ Nano- and Micro-Electromechanical Systems: Fundamentals of Nano- andMicroengineering “ (2nd ed.). CRC Press,2005.
4. Julian W Gardner and Vijay K Varadan, “ Microsensors, MEMS and Smart Devices”, John Wileyand Sons Ltd, 2001, 1st Edition.

REFERENCES:

1. Marc F madou“ Fundamentals of micro fabrication” CRC Press 2002 2nd Edition Marc Madou.
2. M.H.Bao “Micromechanical transducers :Pressure sensors, accelerometers and gyroscopes”,Elsevier, Newyork, 16 Oct 2000, 1st Edition.
3. Maluf, Nadim “An introduction to Micro Electro-mechanical Systems Engineering “AR Techhouse, Boston, June 30 2004, 2nd Edition.
4. Mohamed Gad – el – Hak “MEMS Handbook” Edited CRC Press 2001, 1st Edition.

List of Open Source Software/ Learning website:

1. https://www.academia.edu/Lectures_on_MEMS_and _MICROSYSTEMS_DESIGN_AND_M ANUFACTURE
2. https://nptel.ac.in/courses
3. https://www.iitk.ac.in/me/mems-fabrication
4. http://mems.iiti.ac.in/
5. https://onlinecourses.nptel.ac.in/noc22_ee36/preview

MAPPING COS AND POS:

COs	POs												PSOs			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3	PSO4
CO1	2	3	2	2	2	1	-	-	1	-	1	1	3	2	1	1
CO2	3	3	1	1	1	1	-	-	1	-	1	2	3	2	1	1
CO3	2	2	1	1	3	1	-	-	1	-	1	1	3	3	1	1
CO4	3	1	2	1	2	1	-	-	1	-	1	1	3	2	1	2
CO5	1	2	1	1	3	1	-	-	1	-	1	1	3	3	1	2
Avg	2.2	2.2	1.4	1.2	2.2	1	-	-	1	-	1	1.2	3	2.4	1	1.4

VERTICAL I: POWER ENGINEERING

EE23001	UTILIZATION AND CONSERVATION OF ELECTRICAL ENERGY	L	T	P	C
		3	0	0	3

UNIT I ELECTRIC DRIVES AND TRACTION 9

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

UNIT II ILLUMINATION 9

Introduction - definition and meaning of terms used in illumination engineering - classification of light sources - incandescent lamps, sodium vapour lamps, mercury vapour lamps, fluorescent lamps – design of illumination systems - indoor lighting schemes - factory lighting halls - outdoor lighting schemes - flood lighting - street lighting – UPS- energy saving lamps, LED – working principle of air conditioning system.

UNIT III HEATING AND WELDING 9

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

UNIT IV SOLAR RADIATION AND SOLAR ENERGY COLLECTORS 9

Introduction - solar constant – terrestrial solar radiation - solar radiation geometry – estimation of average solar radiation - physical principles of the conversion of solar radiation into heat – flat-plate collectors - transmissivity of cover system - energy balance equation and collector efficiency - concentrating collector - advantages and disadvantages of concentrating collectors - performance analysis of a cylindrical parabolic concentrating collector.

UNIT V WIND ENERGY 9

Introduction - basic principles of wind energy conversion - site selection considerations - basic components of a WECS (Wind Energy Conversion System) - Classification of WECS - types of wind machines - analysis of aerodynamic forces acting on the blade - performances of wind.

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/ Assignment/ Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc)

1. Analyze the different methods of electric braking for traction motor
2. Design of illumination systems
3. Power quality analysis of electric heating/welding process
4. Analyze the solar collector efficiency
5. Estimation of wind turbine rating based on historic wind profile.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

After completion the above subject, students will be able to

CO1 Ability to choose suitable electric drives for different applications

CO2 Ability to design the illumination systems for energy saving

CO3 Ability to understand the utilization of electrical energy for heating and welding purposes

CO4 Ability to know the effective usage of solar energy for electrical applications

CO5 Able to locate the wind farm for generating electrical energy

TEXT BOOKS:

1. N.V. Suryanarayana, “Utilization of Electric Power”, Wiley Eastern Limited, New Age International Limited, 1993.
2. B.Gupta, “Utilization Electric power and Electric Traction”, S.K.Kataria and sons, 2000.
3. G.D.Rai, “Non-Conventional Energy sources”, Khanna publications Ltd.,New Delhi 1997

REFERENCES:

1. D.P.Kothari, K.C.Singal, Rakesh Ranjan, “Renewable Energy Sources and Emerging Technologies”, PHI Learing Private Limited, 2013.
2. R.K.Rajput, Utilisation of Electric Power, Laxmi publications private Limited.,2007
3. H.Partab, Art and Science of Utilisation of Electrical Energy”, Dhanpat Rai and Co., New Delhi-2004.
4. C.L.Wadhwa, “Generation, Distribution and Utilisation of Electrical Energy”, New Age international Pvt.Ltd.,2003

MAPPING COS AND POS:

COs	POs												PSOs			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	-	-	1	1	-	1	-	-	1	2	2	1	1
CO2	3	2	1	-	-	1	1	-	1	-	-	1	2	2	1	1
CO3	3	2	1	-	-	1	1	-	1	-	-	1	2	2	1	1
CO4	3	2	1	-	-	1	1	-	1	-	-	1	2	2	1	1
CO5	3	2	1	-	-	1	1	-	1	-	-	1	2	2	1	1
Avg	3	2	1	-	-	1	1	-	1	-	-	1	2	2	1	1

EE23002	SUBSTATION ENGINEERING AND AUTOMATION	L	T	P	C
		3	0	0	3

UNIT I SUBSTATION DESIGN DEVELOPMENT 9

Substation Introduction and Classifications, Different bus bar switching schemes for Substation. Standards and Practices, Factors Influencing Substation Design - Altitude, Ambient Temperature, Earthquake and seismic zones, pollution and corrosion etc., Testing of Electrical Equipment, Concept and development of Single Line Diagram. Requirement of substation calculation, Power Factor calculation methods.

UNIT II SUBSTATION EQUIPMENT 9

Selection and sizing of main substation equipment: Transformer, Isolator, Circuit Breaker, surgearrestor. Classifications of MV Switchgear and Key Design Parameters. Station Auxiliary equipment: Diesel Generator System, Basics of AC/DC Auxiliary Power System. Introduction to gas insulated substation: Operating principle of GIS.

UNIT III PROTECTION AND SUBSTATION AUTOMATION 9

Power System protection, Overcurrent and Earth Fault protection and coordination. Distribution Feeder Protection, Transformer – Unit/Main Protection, Familiarization of NUMERICAL Relays. Substation Automation: Evolution of Substation Automation, Communication System Fundamentals-Protocol types. Substation integration and automation functional architecture, Bay Control Unit (BCU), Substation signal list - DI, DO, AI, AO–Remote Terminal Unit RTU.

UNIT IV SUBSTATION DESIGN & LAYOUT ENGINEERING 9

Layout aspects of Outdoor Air Insulated Substation and GIS: Statutory Clearances, Equipment Layout engineering aspects for Outdoor Substation/GIS and guide lines, Cable routing layout, switchyard earthing design as per IEEE80, Importance and Types of Earthing, Earthing Design, Types of Earthing Material, Direct stroke Lightning Protection for switchyard with IS/ IEC 62305. Power & Control, MV Cables, Methods for Cable Installation, Practical aspects of Cable Sizing, Cable accessories, Illumination System.

UNIT V INTERFACE ENGINEERING 9

Civil & Structural Engineering - Familiarization of site development plan, equipment supports structures, foundation for equipment, familiarization of control building and substation building, infrastructure development, Mechanical System- Fire Detection, Alarm System and Fire Suppression System for transformer, Heating, Ventilation and Air-conditioning (HVAC) for Substation.

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/ Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc)

1. Battery sizing for a substation with a load cycle based on IEEE 1115 Ni-cd - A case studyOR
2. DG and auxiliary transformer sizing for a substation auxiliary power supply- A case study
3. Overcurrent Relay coordination in a substation- A case study
4. Earthmat sizing calculation for an outdoor substation based on IEEE80- A case studyOR
5. Direct stroke lightning protection calculation for outdoor switchyard based on IEC 62305- A case study

TOTAL: 45 PERIODS

COURSE OUTCOMES:

After completion the above subject, students will be able to

CO1 Understand the key deciding factors involved in substation design and operation

CO2 Know about the sizing and selection of equipment which forms part of substation

CO3 Know about composite layout design aspects of the substation with different servicesand the challenges including statutory clearances.

CO4 Understand about Interdisciplinary aspects involved in substation design

CO5 Understand different protection and control scheme involved in substation design

CO6 Know about substation automation system and different communication protocol involved for efficient operation of a substation

REFERENCES:

1. McDonald John D, “Electric Power Substations Engineering”, CRC Press, 3rd Edition, 2012
2. Partap Singh Satnam, P.V. Gupta, “Sub-station Design and Equipment”, Dhanpat RaiPublications, 1st Edition, 2013
3. Sunil S. Rao, “Switchgear Protection and Power Systems (Theory, Practice & SolvedProblems)”, Khanna Publications, 14th Edition, 2019 .
4. Electrical substation and engineering & practice by S.Rao, 3rd Edition, Khanna Publishers2015
5. Manual on Substation by Central Board of irrigation and Power (CBIP) Publication No 342.,2006.
6. Substation automation system Design and implementation by Evelio Padilla by WileyPublications, 1st Edition, 2015 November.

MAPPING COS AND POS:																
COs	**POs**												**PSOs**			
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO1 0**	**PO1 1**	**PO1 2**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**
CO1	3	2	2	2	-	1	-	-	-	-	-	-	3	-	2	1
CO2	3	2	2	2	-	1	-	-	-	-	-	-	3	-	2	1
CO3	3	2	2	2	-	1	-	-	-	-	-	-	3	-	2	1
CO4	3	2	2	2	-	1	-	-	-	-	-	-	3	-	2	1
CO5	3	2	2	2	-	1	-	-	-	-	-	-	3	-	2	1
Avg	3	2	2	2	-	1	-	-	-	-	-	-	3	-	2	1

EE23003	HVDC AND FACTS	L	T	P	C
		3	0	0	3

UNIT I INTRODUCTION 9

Reactive power control in electrical power transmission lines–load & system compensation, Uncompensated transmission line–shunt and series compensation. Need for HVDC Transmission, Comparison between AC & DC Transmission, Types of HVDC transmission System.

UNIT II STATIC VAR COMPENSATOR (SVC) AND THYRISTOR CONTROLLED SERIES COMPENSATOR (TCSC) 9

VI characteristics of FC+TSR, TSC+TSR, Voltage control by SVC–Advantages of slope in dynamic characteristics–Influence of SVC on system voltage–Design of SVC voltage regulator, Thyristor Controlled Series Compensator (TCSC), Concept of TCSC, Operation of the TCSC– Different modes of operation, Applications.

UNIT III VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS 9

Static Synchronous Compensator (STATCOM)–Principle of operation–V-I Characteristics. Applications: Steady state power transfer-enhancement of transient stability-prevention of voltage instability. SSSC-operation of SSSC VI characteristics, Enhancement in Power transfer capability –, UPFC — Operation Principle Applications.

UNIT IV LINE COMMUTATED HVDC TRASMISSION 9

Operation of Gratz bridge - Effect of delay in Firing Angle — Effect of commutation overlap - Equivalent circuit,. Basic concept of HVDC transmission. Modes of operations and control of power flow, CC and CIA mode of operation.

UNIT V VSC BASED HVDC TRANSMISSION 9

Basic 2 level IGBT inverter operation- 4 Quadrant operation- phase angle control- dq Control- Control of power flow in VSC based HVDC Transmission, Topologies of MTDC system.

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/ ContentPreparation / Quiz/ Surprise Test / Solving GATE questions/ etc)

1. Simulation of FC+TSR connected to IEEE 5 bus system
2. Realization of reactive power, support by SVC in open loop and closed loop control in simulation.
3. Regulation of line flows employing TCSC and TSSC in closed loop control insimulation
4. Simulation of two terminal HVDC Link, closed loop control in CC and CIA mode in simulation
5. Realization of four quadrant operation of VSC in open loop mode in simulation

TOTAL: 45 PERIODS

COURSE OUTCOMES:

After completion the above subject, students will be able to

CO1 To Identify and understand the problems in AC transmission systems and understand the need for Flexible AC transmission systems and HVDC Transmission

CO2 To understand the operation and control of SVC and TCSC and its applications to enhance the stability and damping.

CO3 To Analyze basic operation and control of voltage source converter based FACTS controllers

CO4 To demonstrate basic operation and control of Line Commutated HVDC Transmission

CO5 To explain the d-q control based operation of VSC based HVDC Transmission

TEXT BOOKS:

1. R.Mohan Mathur, Rajiv K.Varma,“Thyristor–Based Facts Controllers for ElectricalTransmission Systems”, IEEE press andJohnWiley&Sons,Inc,2002.
2. Narain G.Hingorani,“Understanding FACTS-Concepts and Technology of Flexible AC Transmission Systems”, Standard Publishers Distributors,Delhi-110006,2011.

REFERENCES:

1. K.R.Padiyar,”FACTS Controllersin PowerTransmission and Distribution”, New Age International (P) Limited, Publishers, New Delhi, 2008.
2. A.T.John,“FlexibleA.C.TransmissionSystems”,InstitutionofElectricalandElectronic Engineers(IEEE), 1999.
3. V. K.Sood, HVDC and FACTS controllers–Applications of Static Converters in Power System, APRIL2004,KluwerAcademic Publishers,2004.

MAPPING COS AND POS:

COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	2	2	2	1	1	-	-	2	2	-	1	3	1	1	3
CO2	3	2	2	2	1	1	-	-	2	2	-	1	3	1	1	3
CO3	3	2	2	2	1	1	-	-	2	2	-	1	3	1	1	3
CO4	3	2	2	2	1	1	-	-	2	2	-	1	3	1	1	3
CO5	3	2	2	2	1	1	-	-	2	2	-	1	3	1	1	3
Avg	3	2	2	2	1	1	-	-	2	2	-	1	3	1	1	3

EE23004	ENERGY MANAGEMENT AND AUDITING	L	T	P	C
		3	0	0	3

UNIT I GENERAL ASPECTS OF ENERGY MANAGEMENT AND ENERGY AUDIT 9

Commercial and Non-commercial energy - final energy consumption - energy needs of growing economy - energy pricing - energy conservation and its importance - Re-structuring of the energy supply sector - Energy Conservation Act 2001, Energy Conservation (Amendment) Act, 2010, and its features - electricity tariff - Thermal Basics - need and types of energy audit - Energy management/audit approach-understanding energy costs - maximizing system efficiencies -optimizing the input energy requirements - energy audit instruments.

UNIT II MATERIAL AND ENERGY BALANCE 9

Methods for preparing process flow - material and energy balance diagrams - Energy policy purpose - location of energy management - roles and responsibilities of energy manager — employees training and planning- Financial Management: financial analysis techniques, simple payback period, return on investment, net present value, internal rate of return.

UNIT III ENERGY EFFICIENCY IN THERMAL UTILITIES 9

Introduction to fuels - properties of fuel oil, coal and gas - principles of combustion - combustion of oil, coal and gas - Boilers: Types, combustion in boilers, performances evaluation, analysis of losses - energy conservation opportunities - FBC boilers - Steam System: Properties of steam, assessment of steam distribution losses, steam leakages, steam trapping, condensate and flash steam recovery system, identifying opportunities for energy savings - Furnaces: Classification, general fuel economy measures in furnaces, excess air, heat distribution, temperature control, draft control, waste heat recovery — Refractory : types, selection and application of refractories, heat loss - Cogeneration: classification and saving potentials - Case Study.

UNIT IV ENERGY EFFICIENCY IN COMPRESSED AIR SYSTEM 9

Compressed Air System: Types of air compressors - efficient compressor operation - Compressed air system components - leakage test - savings opportunities - Refrigeration System: Vapour compression refrigeration cycle — refrigerants - coefficient of performance - factors affecting Refrigeration and Air conditioning system - savings opportunities - Vapour absorption refrigeration system: working principle - types and comparison with vapour compression system - saving potential - Cooling Tower: Types and performance evaluation, efficient system operation - flow control strategies and energy saving - Diesel Generating system: Factors affecting selection - energy performance assessment of diesel conservation avenues - Case Study.

UNIT V ENERGY EFFICIENCY IN ELECTRICAL UTILITIES 9

Electrical load management and maximum demand control - power factor improvement and its benefit - selection and location of capacitors - performance assessment of PF capacitors - automatic power factor controllers - transformer losses - Electric motors: Types - losses in induction motors - motor efficiency - factors affecting motor performance - rewinding and motor replacement issues - energy saving opportunities with energy efficient motors - soft starters with energy saver - variable speed drives — Fans and blowers: Types - efficient system operation - flow control strategies -Pumps and Pumping System: Types - system operation - flow control methods - Lighting System: Light source, choice of lighting, luminance requirements — ballast - occupancy sensors - energy efficient lighting controls - energy conservation avenues - Case Study.

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/ Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc)

1. Study of Energy Conservation and Energy Audit Using Energy Audit Instruments.
2. Performance Analysis of Electric Motor and Energy Efficient Motor (EEM)
3. Performance Analysis of fan characteristic curves at different operating points
4. Case study of illumination system
5. Performance Analysis of Compressors

TOTAL: 45 PERIODS

COURSE OUTCOMES:

After completion the above subject,

CO1 Students able to acquire knowledge in the field of energy management and auditing.

CO2 Learned the about basic concepts of economic analysis, material and energy balance.

CO3 Able to design the effective thermal utility system.

CO4 Able to improve the efficiency in compressed air system.

CO5 Acquired the design concepts in the field of lighting systems, light sources and variousforms of cogeneration.

TEXT BOOKS:

1. Mehmet Kanoglu, Yunus A Cengel, "Energy Efficiency and Management forEngineers", McGraw-Hill Education, First Edition, 2020.

REFERENCES:

1. Moncef Krati, 'Energy Audit of Building Systems: An Engineering Approach', Third Edition,CRC Press, Dec.2020.
2. Sonal Desai, 'Handbook of Energy Audit', McGraw Hill Education (India) Private Limited, 2015.
3. Michael P.Deru, Jim Kelsey, 'Procedures for Commercial Building Energy Audits',American Society of Heating, Refrigerating and Air conditioning Engineers, 2011.
4. Thomas D.Eastop, 'Energy Efficiency: For Engineers and Technologists', LongmanScientific & Technical, 1990, 1st Edition.
5. Daniel Martinez, Ben W. Ebenhack, Travis Wagner, "Energy Efficiency Concepts and Calculations", First Edition, Elsevier Science, 2019
6. "Energy Efficiency in Electrical Utilities", Third Edition, Bureau of Energy Efficiency (BEE), India, 2010
7. Al Thumann, William J.Younger, Terry Niehus, "Handbook of Energy Audits", 8th Edition,The Fairmont Press, Inc., 2010.

List of Open Source Software/ Learning website:

1. https://facilio.com/blog/commercial-energy-audit
2. https://www.sciencedirect.com/science/article/pii/S2212827114004491
3. https://mppolytechnic.ac.in/mpstaff/notes_upload_photo/ CS595EnergyEfficiencyinElectricalUtilities-5391.pdf
4. http://knowledgeplatform.in/wp-content/uploads/2017/03/1.3-Energy-management-Audit.pdf

MAPPING COS AND POS:																
COs	**POs**												**PSOs**			
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**
CO1	3	2	2	1	1	1	1	1	1	-	-	-	-	3	2	1
CO2	3	2	2	1	1	1	1	1	1	-	-	-	-	3	2	1
CO3	3	2	2	1	1	1	1	1	1	-	-	-	-	3	2	1
CO4	3	2	2	1	1	1	1	1	1	-	-	-	-	3	2	1
CO5	3	2	2	1	1	1	1	1	1	-	-	-	-	3	1	1
Avg	3	2	2	1	1	1	1	1	1	-	-	-	-	3	1.8	1

EE23005	POWER SYSTEM TRANSIENTS	L	T	P	C
		3	0	0	3

UNIT I INTRODUCTION AND SURVEY 9

Sources of different types of transients - RL circuit transient with sine wave excitation - double frequency transients - basic transforms of the RLC circuit transients - study of transients in system planning - Importance of grounding.

UNIT II SWITCHING TRANSIENTS 9

Basic concept of switching transients - resistance switching and equivalent circuit for interruptingthe resistor current - load switching and equivalent circuit - waveforms for transient voltage acrossthe load and the switch - normal and abnormal switching transients. Current suppression - currentchopping - effective equivalent circuit - capacitance switching with a restrike, with multiple restrikes - ferro resonance.

UNIT III LIGHTNING TRANSIENTS 9

Theories of cloud formation - mechanism of lightning discharges and characteristics of lightning strokes — model for lightning stroke - factors contributing to good line design - protection using ground wires - tower footing resistance - Interaction between lightning and power system.

UNIT IV TRAVELING WAVES ON TRANSMISSION LINE COMPUTATION OF TRANSIENTS 9

Computation of transients - transient response of systems with series and shunt lumped parameters and distributed lines. Traveling wave concept - step response - Bewely's lattice diagram - standing waves and natural frequencies - reflection and refraction of travelling waves. Computation of overvoltages using EMTP.

UNIT V TRANSIENTS IN INTEGRATED POWER SYSTEM 9

The short line and kilometric fault - distribution of voltages in a power system - Line dropping andload rejection - voltage transients on closing and reclosing lines - overvoltage induced by faults -switching surges on integrated system Qualitative application of EMTP for transient computation.

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc)

1. Simulation of circuit transients
2. Computation of over voltages for switching surges
3. Computation of over voltages for lightning surges
4. Computation of transients

TOTAL: 45 PERIODS

COURSE OUTCOMES:

After completion the above subject, students will be able to

CO1 Explain the principles of transients and its concepts.
CO2 Know the different types of switching transients and the way to draw the necessary equivalent circuit.
CO3 Explain the concepts behind lighting and the way to protect the same.
CO4 Compute the transient behavior in transmission line.
CO5 Explain the behavior of the Circuit during switching and to learn the simulation tool.

TEXT BOOKS:

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

REFERENCES:

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

MAPPING COS AND POS:

COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	2	2	1	1	1	-	-	-	-	-	1	3	-	2	-
CO2	3	2	2	1	1	1	-	-	-	-	-	1	3	-	2	-
CO3	3	2	2	1	1	1	-	-	-	-	-	1	3	-	2	-
CO4	3	2	2	1	1	1	-	-	-	-	-	1	3	-	2	-
CO5	3	2	2	1	1	1	-	-	-	-	-	1	3	-	2	-
Avg	3	2	2	1	1	1	-	-	-	-	-	1	3	-	2	-

EE23006	SMART GRID	L	T	P	C
		3	0	0	3

UNIT I INTRODUCTION 9

Evolution of Energy Systems, Concept, Definitions and Need, Difference between Conventional & Smart Grid, Drivers, structures, functions, opportunities, challenges and benefits of Smart Grid, Basics of Micro grid, National and International Initiatives in Smart Grid.

UNIT II SMART METERING 9

Introduction to Advanced Metering infrastructure (AMI) - drivers and benefits, AMI protocols, standards and initiatives, AMI needs in the smart grid, Real time management and control, Phasor Measurement Unit (PMU).

UNIT III SMART GRID TECHNOLOGIES (Transmission) 9

Technology Drivers, Smart energy resources, Smart substations, Substation Automation, Feeder Automation, Transmission systems: Energy Management System, Wide area Monitoring, Protection and control.

UNIT IV SMART GRID TECHNOLOGIES (Distribution) 9

DMS, Volt/VAr control, Fault Detection, Isolation and service restoration, Outage management, High-Efficiency Distribution Transformers, Phase Shifting Transformers, Electric Vehicles.

UNIT V SMART GRID ENABLING TERCHNOLOGIES 9

Local Area Network (LAN), Home Area Network (HAN), Wide Area Network (WAN), Broadband over Power line (BPL), IP based Protocols, Computing technologies for Smart Grid applications (Web Service to CLOUD Computing), Role of big data and IoT, Cyber Security for Smart Grid.

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/ Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc)

1. Assignment-Familiarization of National and International Initiatives in Smart Grid
2. Simulation of smart meter using (MATLAB/ ETAP/SCILAB/ LABVIEW/ Proteus/Equivalent open sourcesoftware).
3. Visit to a substation for analysing the Automation Technologies like Monitoring, Protection and control.
4. Awareness about High- Efficiency Distribution Transformers, Phase Shifting Transformers in asubstation.
5. Introduction to recent technologies in electric vehicles and understanding the operation of EV,HEV andPHEV.
6. Simulation of IoT based digital communication system for smart grid applications.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

After completion the above subject, students will be able to

CO1 understand the importance and objectives of Power System Grid.
CO2 know and understand the concept of a smart grid.
CO3 identify and discuss smart metering devices and associated technologies.
CO4 get an overview of Microgrid and Electric Vehicle Technology.
CO5 have an up to date knowledge on the various computing technologies; to understand the role of Big Data and IoT for effective and efficient operation of Smart Grid.

TEXT BOOKS:

1. Smart Grids Advanced Technologies and Solutions, Second Edition, Edited by Stuart Borlase,CRC, 2018.
2. Janaka Ekanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, “Smart Grid:Technology and Applications”, John Wiley,2012
3. James Momoh ,Smart Grid Fundamentals of Design and Analysis, IEEE press 2012.

REFERENCES:

1. Ahmed F. Zobaa, Trevor J. Bihl, Big data analytics in future power systems, 1st Edition, CRC press 2018.
2. C. Gungor et al., "Smart Grid Technologies: Communication Technologies and Standards," in IEEE Transactions on Industrial Informatics, vol. 7, no. 4, pp. 529-539, Nov. 2011.doi: 10.1109/TII.2011.2166794.
3. X. Fang, S. Misra, G. Xue and D. Yang, "Smart Grid ── The New and Improved Power Grid: A Survey," in IEEE Communications Surveys & Tutorials, vol. 14, no. 4, pp. 944- 980, Fourth Quarter 2012. doi: 10.1109/SURV.2011.101911.00087.
4. Stuart Borlase “Smart Grid : Infrastructure, Technology and Solutions”, CRC Press 2012.

MAPPING COS AND POS:

COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	2	1	3	1	1	1	-	1	-	-	-	1	2	-	1	2
CO2	2	1	3	1	1	1	-	1	-	-	-	1	2	-	1	2
CO3	2	1	3	1	1	1	-	1	-	-	-	1	2	-	1	2
CO4	2	1	3	1	1	1	-	1	-	-	-	1	2	-	1	2
CO5	2	1	3	1	1	1	-	1	-	-	-	1	2	-	1	2
Avg	2	1	3	1	1	1	-	1	-	-	-	1	2	-	1	2

EE23007	RESTRUCTURED POWER MARKET	L	T	P	C
		3	0	0	3

UNIT I INTRODUCTION 9

Deregulation of power industry, unbundling of electric utilities, Issues involved in deregulation – Fundamentals of Economics: Consumer and suppliers behavior, Total utility and marginal utility, Law of diminishing marginal utility, Elasticity of demand and supply curve, Market equilibrium, Consumer and supplier surplus, Global welfare, Deadweight loss - The Philosophy of Market Models.

UNIT II PRICING OF TRANSMISSION NETWORK AND CONGESTION MANAGEMENT 9

Pricing of transmission network: wheeling - principles of transmission pricing - transmission pricing methods - Marginal transmission pricing paradigm - Composite pricing paradigm

Importance of congestion management in deregulated environment - Classification of congestion management methods - Calculation of ATC - Nodal pricing - Inter-zonal Intra-zonal congestion management - Price area congestion management.

UNIT III LOCATIONAL MARGINAL PRICES(LMP) AND FINANCIAL TRANSMISSION RIGHTS 9

Fundamentals of locational marginal pricing - Lossless DCOPF model for LMP calculation - Loss compensated DCOPF model for LMP calculation - ACOPF model for LMP calculation - Risk Hedging Functionality of Financial Transmission Rights(FTR) - FTR issuance process - Treatment of revenue shortfall - Secondary trading of FTRs - Flow Gate rights - FTR and market power.

UNIT IV ANCILLARY SERVICE MANAGEMENT 9

Types of ancillary services - Load-generation balancing related services - Voltage control and reactive power support services - Black start capability service - Mandatory provision of ancillary services - Markets for ancillary services - Co-optimization of energy and reserve services.

UNIT V MARKET EVOLUTION 9

US market: California energy market - Reforms in Indian power sector: Framework of Indian power sector, Reform initiatives, Availability Based Tariff (ABT), The Electricity Act, Open Access issues, Power exchange, role of RLDC and NLDC.

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc)

1. Analysis of social welfare maximization with different objectives
2. Analysis of transmission pricing using any one of the relevant software tools
3. Analysis of ATC calculations using any one of the relevant software tools
4. LMP calculations using any one of the relevant software tools
5. Co-optimization of energy and reserve services using any one of the relevant software tools
6. Analysis of ABT components

TOTAL: 45 PERIODS

COURSE OUTCOMES:

After completion the above subject, students will be able to

CO1 Understand the process of restructuring of power industry and analyze the philosophy of market models

CO2 analyze various methods for calculating wheeling charges and congestion

management in deregulated power system

CO3 analyze the locational marginal pricing and financial transmission rights

CO4 analyze the ancillary service management

CO5 explain the evolution of Indian and US power markets

TEXT BOOKS:

1. Mohammad Shahidehpour, Muwaffaq Alomoush, “Restructured electrical power systems: operation, trading and volatility” Marcel Dekker Pub., 2001, 1st Edition.
2. Kankar Bhattacharya, MathH.J.Boolen, and Jaap E.Daadler, "Operation of restructured power systems”, Kluwer Academic Pub.,2001, 1st Edition.

REFERENCES:

1. Sally Hunt, "Making competition work in electricity”, JohnWilley and Sons Inc. 2002.
2. Steven Stoft, Power System Economics: Designing Markets for Electricity”, Wiley-IEEE Press,2002.
3. Allen. J. Wood and Bruce F. Wollen berg, ‘Power Generation, Operation and Control’, John Wiley & Sons, Inc., 2016, 3rd Edition.

List of Open Source Software/ Learning website:

1. S.A. Khaparde, A.R. Abhyankar, "Restructured Power Systems", NPTEL Course, https://nptel.ac.in/courses/108101005/.

MAPPING COS AND POS:

COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	2	2	2	-	1	-	1	-	1	1	-	3	-	-	-
CO2	3	2	2	2	-	1	-	1	-	1	1	-	3	-	-	-
CO3	3	2	2	2	-	1	-	1	-	1	1	-	3	-	-	-
CO4	3	2	2	2	-	1	-	1	-	1	1	-	3	-	-	-
CO5	3	2	2	2	-	1	-	1	-	1	1	-	3	-	-	-
Avg	3	2	2	2	-	1	-	1	-	1	1	-	3	-	-	-

EE23008	SUSTAINABLE HV INSULATION SYSTEM	L	T	P	C
		3	0	0	3

UNIT I SUSTAINABLE AND ENVIRONMENT FRIENDLY ENERGY AND PRODUCTS 9

Carbon footprint, global warming potential, environment requirement for any product and system.

UNIT II GREEN GASEOUS INSULATORS 9

SF6 gas and its hazardous environmental effects alternate gases gaseous mixtures and other sources and it's properties.

UNIT III GREEN LIQUID INSULATORS 9

Hazardous effects of existing liquid dielectric materials (such as organic oil), alternate sources of environment friendly liquid dielectrics such as ester oil, vegetable oils, dielectric and it's properties.

UNIT IV GREEN SOLID INSULATORS 9

Hazardous effects of existing solid dielectric materials, alternate sources of environment friendly solid dielectric and its properties.

UNIT V EVOLVING STANDARDS FOR GREEN INSULATION SYSTEMS 9

Requirements, evolving standards of management, testing, usage and disposal of alternate insulation systems, Major applications, and standards.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

After completion the above subject, students will be able to

- **CO1** Know about sustainable and environment friendly energy and products.
- **CO2** Describe the alternate green gaseous insulators.
- **CO3** Describe the alternate green liquid insulators.
- **CO4** Describe the alternate green solid insulators.
- **CO5** Elaborate the standards for green insulation systems.

REFERENCES:

1. Dielectric Materials for Electrical Engineering, Juan Martinez-Vega (Editor), ISBN: 978-1-118-55741-9, March 2013, Wiley-ISTE
2. Carbon Footprint Analysis: Concepts, Methods, Implementation, and Case Studies (Systems Innovation Book Series) – 18 June 2012
3. The Carbon Footprint Handbook, Edited By Subramanian Senthilkannan Muthu, ISBN 9781482262223, Published September 23, 2015 by CRC Press
4. Design of Green Liquid Dielectrics for Transformers: An Experimental ApproachBiodegradable Insulating Materials for Transformers Forthcoming. Authors: T. Mariprasath, , Victor Kirubakaran, , Perumal Saraswathi, , Cheepati Kumar Reddy, , Prakasha Kunkanadu Rajappa, ISBN: 9788770041522 e-ISBN: 9788770041225
5. Gas Discharge and Gas Insulation: 6, ISBN-10: 3662514699, ISBN-13: 978-3662514696
6. Industrial Applications of Green Solvents – Volume I, Eds. Inamuddin, Mohd Imran Ahamed and Abdullah M. Asiri, Materials Research Foundations Vol. 50, Print ISBN 978-1-64490-022-2, ePDF ISBN 978-1-64490-023-9, DOI: 10.21741/9781644900239
7. https://www.iec.ch/dyn/www/f?p=103:7:0::::FSP_ORG_ID,FSP_LANG_ID:1275,25

8. https://www.iec.ch/ords/f?p=103:41:628762356646470::::FSP_ORG_ID,FSP_LANG_ID:3237,25
9. https://www.iec.ch/dyn/www/f?p=103:7:0::::FSP_ORG_ID,FSP_LANG_ID:1299,25
10. https://www.iec.ch/sdgs/sdg13
11. ht_ https://highperformanceinsulation.eu/wp-content/uploads/2016/08/sustainability_a_guide.pdf
12. https://www.ictfootprint.eu/en/iec-tr-627252013-factsheet

MAPPING COS AND POS:																
COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3	PSO 4
CO1	2	1	2	2	-	1	3	-	1	-	-	2	3	-	2	2
CO2	2	1	2	2	-	1	3	-	1	-	-	2	3	-	2	2
CO3	2	1	2	2	-	1	3	-	1	-	-	2	3	-	2	2
CO4	2	1	2	2	-	1	3	-	1	-	-	2	3	-	2	2
CO5	2	1	2	2	-	1	3	-	1	-	-	2	3	-	2	2
Avg	2	1	2	2	-	1	3	-	1	-	-	2	3	-	2	2

VERTICAL II: CONVERTERS AND DRIVES

EE23009	ELECTRICAL MACHINES - III	L	T	P	C
		3	0	0	3

UNIT I PERMANENT MAGNET BRUSHLESS DC MOTORS 9

Fundamentals of Permanent Magnets- Types- Principle of operation- Magnetic circuit analysis- EMF and Torque equations- Characteristics and control.

UNIT II PERMANENT MAGNET SYNCHROUNOUS MOTORS 9

Principle of operation – EMF and torque equations - Phasor diagram - Power controllers–performance characteristics – Digital controllers – Constructional features, operating principle and characteristics of synchronous reluctance motor.

UNIT III SWITCHED RELUCTANCE MOTORS 9

Constructional features –Principle of operation- Torque prediction –performance Characteristics-Power controllers – Control of SRM drive- Sensor less operation of SRM – Applications.

UNIT IV STEPPER MOTORS 9

Constructional features –Principle of operation –Types – Different modes of excitation - Torque equation – Characteristics – Drive circuits – Closed loop control – Applications.

UNIT V STUDY OF OTHER SPECIAL ELECTRICAL MACHINES 9

Principle of operation and characteristics of Hysteresis motor – Universal motor – Linear induction motor – Applications.

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc)

Using electromagnetic software

1. Simulation of BLDC based drive.
2. Simulation of SRM based drive.
3. Simulation of position control using stepper motor
4. Simulation of PMSM drive.
5. Simulation of other special machines

TOTAL: 45 PERIODS

COURSE OUTCOMES:

After completion the above subject, students will be able to

- **CO1** model and analyze power electronic systems and equipment usingcomputational software.
- **CO2** optimally design magnetics required in special machines based drive systemsusing FEM based software tools.
- **CO3** analyse the dynamic performance of special electrical machines
- **CO4** understand the operation and characteristics of other special electrical machines.
- **CO5** design and conduct experiments towards research.

REFERENCES:

1. T.J.E. Miller, ‘Brushless magnet and Reluctance motor drives’, Clarendon press, London, 1989
2. T.Kenjo, ‘ Stepping motors and their microprocessor controls’, Oxford University press, New

Delhi, 2000 Dekker 2009
3. R. Krishnan - Switched Reluctance Motor Drives Modeling, Simulation, Analysis, Design, and Applications -CRC Press 2017.
4. Bilgin, Berker Emadi, Ali Jiang, James Weisheng - Switched reluctance motor drives: fundamentals to applications-CRC 2019.
5. Ramu Krishnan - Permanent Magnet Synchronous and Brushless DC Motor Drives -CRC Press,Marcel Applications -CRC Press 2009

MAPPING COS AND POS:																
COs	**POs**												**PSOs**			
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**
CO1	2	3	2	2	3	1	-	-	-	-	-	1	3	3	2	2
CO2	2	3	3	2	3	1	-	-	-	-	-	1	3	3	2	2
CO3	2	3	3	2	3	1	-	-	-	-	-	1	3	3	2	2
CO4	1	1	1	2	2	1	-	-	-	-	-	1	2	2	2	2
CO5	1	2	2	3	1	1	-	-	-	-	-	1	2	2	1	3
Avg	1.6	2.4	2.2	2.2	3	1	-	-	-	-	-	1	2.6	2.6	1.8	2.2

EE23010	ANALYSIS OF ELECTRICAL MACHINES	L	T	P	C
		3	0	0	3

UNIT I MODELING 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 of a DC Machine usingstate equations- Shunt, Series and Compound-Time of domain block diagram of DC Machine.

UNIT II REFERENCE FRAME THEORY 9

Historical background –Necessary for transformation and types- – transformation of variables from stationary to arbitrary reference frame - variables observed from several frames of reference. Principles of 'dq' transformation-Application of dq transformation to stationery elements (Three phase R,C, RL Circuits)-Problems

UNIT III INDUCTION MACHINES 9

Three phase induction machine - equivalent circuit– 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 and arbitrary reference variable form.

UNIT IV SYNCHRONOUS MACHINES 9

Three phase synchronous machine - voltage and torque equations in machine variables and application of transformation for synchronous machines (Park's equations)-voltage and torque equations.

UNIT V MULTIPHASE (MORE THAN THREE-PHASE) MACHINES 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.

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc)

1. Modeling of DC machines.
2. Simulation under no-load and loaded conditions for a PMDC motor
3. Simulation of smooth starting for DC motor.
4. Simulation under no-load and load conditions of a three phase induction machine in machine variable form and arbitrary reference variable form.
5. Simulation under no-load and load conditions of a three phase synchronous machine in machinevariable form and arbitrary reference variable form.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

After completion the above subject, students will be able to

CO1 Find the modeling for a brushed DC-Motor (Shunt, Series, Compound and separatelyexcised motor) and to simulate DC motors using state models.

CO2 Apply reference frame theory for, resistive and reactive elements (three phase).

CO3 Compute the equivalent circuit and torque of three phase induction motor and synchronousmotor in machine variable and arbitrary reference frame variable.

CO4 Find the need and advantages of multiphase machines.
CO5 Demonstrate the working of multiphase induction and synchronous machine.
CO6 Compute the model of three phase and multiphase induction and synchronous machine.

REFERENCES:

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, 1st Edition.
3. Paul C. Krause, Oleg Wasynczuk, Scott D. Sudhoff, Steven D. Pekarek, "Analysis of Electric Machinery and Drive Systems", 3rd Edition, Wiley-IEEE Press, 2013.
4. R. Krishnan, Electric Motor & Drives: Modeling, Analysis and Control, Pearson Education, 1st Imprint, 2015, 1st Edition.
5. R.Ramanujam, Modeling and Analysis of Electrical Machines, I.k.International Publishing HousePvt.Ltd,2018.
6. Chee Mun Ong, Dynamic Simulation of Electric Machinery using MATLAB, Prentice Hall, 1997, 1st Edition.
7. Atif Iqbal,Shaikh Moinoddin, Bhimireddy Prathap Reddy, Electrical Machine Fundamentals with Numerical Simulation using MATLAB/SIMULINK, Wiley,2021,1st Edition

MAPPING COS AND POS:

COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3	PSO 4
CO1	2	3	2	2	2	-	-	-	-	-	-	1	3	2	1	1
CO2	3	3	1	1	1	-	-	-	-	-	-	1	3	3	1	1
CO3	2	2	1	1	3	-	-	-	-	-	-	1	3	3	1	1
CO4	2	2	2	1	2	-	-	-	-	-	-	1	3	3	1	2
CO5	2	2	1	1	3	-	-	-	-	-	-	1	3	3	1	2
Avg	2.2	3	1.4	1.2	2.2	-	-	-	-	-	-	1	3	2.8	1	1.4

EE23011	MULTILEVEL POWER CONVERTERS	L	T	P	C
		3	0	0	3

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 (DCMC) 9

Introduction – Converter structure and Functional Description – Modulation scheme for diode clamped Multilevel converters– Voltage balance Control –Boundary of voltage balancing in DCMC converters –Performance results.

UNIT IV FLYING CAPACITOR MULTILEVEL CONVERTER (FCMC) 9

Introduction – Flying Capacitor topology – Modulation scheme for the FCMC – Dynamic voltagebalance of FCMC.

UNIT V CASCADED ASYMMETRIC MULTILEVEL INVERTER 9

Multilevel inverter (MLI) with reduced switch count-structures, working principles - pulse generation methods for the inverter with carrier signals and without carrier signals.

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/ Assignment /Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc)

1. Simulation of Fixed PWM, Sinusoidal PWM for an inverter,
2. Simulation of H bridge inverter with R load
3. Simulation of three level diode clamped MLI with R load.
4. Simulation of three level capacitor clamped MLI with R load
5. Simulation of MLI with reduced switch configuration.

TOTAL:45 PERIODS

COURSE OUTCOMES:

After completion the above subject, students will be able to

CO1 understand the different topologies of multilevel inverters (MLIs) with and without DC link capacitor.

CO2 analyze the performance of MLIs with Bipolar Pulse Width Modulation (PWM) Unipolar PWM Carrier-Based PWM Schemes Phase Level Shifted Multicarrier Modulation.

CO3 comprehend the working principles of Cascaded H-Bridge MLI, diode clamped MLI,flying capacitor MLI and MLI with reduced switch count.

CO4 analyze the voltage balancing performance in Diode clamped MLI.

CO5 simulate three level, capacitor clamed and diode clamped MLI with R and RL load.

TEXT BOOKS:

1. Rashid M.H, ”Power Electronics Circuits, Devices and Applications”, Prentice Hall India, Third Edition, New Delhi, 2014 Pearson 4th edition.
2. Sergio Alberto Gonzalez, Santiago Andres Verne, Maria Ines Valla, ”Multilevel Converters for Industrial Applications”, CRC Press, 22-Jul-2013, 20171st Edition.
3. Bin Wu, Mehdi Narimani, High Power Converters and AC drives by IEEE press 2017, 2nd Edition.

REFERENCES:

1. Thomas A. Lipo, Pulse Width Modulation for Power Converters: Principles and Practice, D.Grahame Holmes, John Wiley & Sons, Oct-2003, 1st Edition.
2. Fang Lin Luo, Hong Ye,Advanced DC/AC Inverters: Applications in Renewable Energy,CRC Press, 22-Jan-2013, 2017, 1st Edition.
3. Hani Vahedi, Mohamed Trabelsi, Single-DC-Source Multilevel Inverters, Springer, 2019, 1st Edition.
4. Ersan Kabalcı, Multilevel Inverters Introduction and Emergent Topologies, Academic Press Inc,2021, 1st Edition.
5. Iftekhar Maswood, Dehghani Tafti, Advanced Multilevel Converters and Applications in Grid Integration, Wiley, 2018, 1st Edition.

MAPPING COS AND POS:

COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	2	2	2	1	2	1	-	-	-	-	-	1	3	2	1	2
CO2	2	2	2	1	2	1	-	-	-	-	-	1	3	2	1	2
CO3	2	3	2	1	2	1	-	-	-	-	-	1	3	2	2	3
CO4	2	2	2	1	2	1	-	-	-	-	-	1	3	2	2	2
CO5	2	2	2	1	2	1	-	-	-	-	-	1	3	2	2	2
Avg	2	2.2	2	1	2	1	-	-	-	-	-	1	3	2	1.6	2.2

EE23012	ELECTRICAL DRIVES	L	T	P	C
		3	0	0	3

UNIT I DRIVE CHARACTERISTICS 9

Electric drive and its classification – Equations governing motor load dynamics – steady state stability – multi quadrant Dynamics: acceleration, deceleration, starting & stopping – typical load torque characteristics – Selection of motor.

UNIT II CONVERTER / CHOPPER FED DC MOTOR DRIVE 9

Steady state analysis of the single and three phase converter fed separately excited DC motor drive – continuous and discontinuous conduction – Time ratio and current limit control – 4 quadrant operation of converter / chopper fed drive.

UNIT III INDUCTION MOTOR DRIVES 9

Stator voltage control – energy efficient drive – v/f control – constant air gap flux – field weakening mode – voltage / current fed inverter – closed loop control.

UNIT IV SYNCHRONOUS MOTOR DRIVES 9

V/f control and self-control of synchronous motor: Margin angle control and power factor control – permanent magnet synchronous motor.

UNIT V DESIGN OF CONTROLLERS FOR DRIVES 9

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

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc)

1. Simulation of converter and chopper fed DC drive
2. Simulation of closed loop operation of stator voltage control of induction motordrive
3. Simulation of closed loop operation of v/f control of induction motor drive
4. Simulation of synchronous motor drive
5. Simulation of closed loop control of dc drive

TOTAL: 45 PERIODS

COURSE OUTCOMES:

After completion the above subject, students will be able to

CO1 understand the basic requirements of motor selection for different load profiles.
CO2 Analyse the steady state behavior and stability aspects of drive systems.
CO3 Analyse the dynamic performance of the DC drive using converter and chopper control.
CO4 Simulate the AC drive.
CO5 Design the controller for electrical drives.

TEXT BOOKS:

1. Gopal K.Dubey, Fundamentals of Electrical Drives, Narosa Publishing House, 2nd Edition January 2010.
2. Bimal K.Bose. Modern Power Electronics and AC Drives, Pearson Education, 2002 1st Edition.

REFERENCES:

1. S.K.Pillai, A First course on Electrical Drives, Wiley Eastern Limited, 3rd Edition 2012.
2. Murphy J.M.D and Turnbull, Thyristor Control of AC Motor, Pergamon Press, Oxford 1988, 1st Edition.
3. Gopal K.Dubey, Power semiconductor controlled Drives, Prentice Hall Inc., New Jersey,1989,1st Edition.
4. R.Krishnan, Electric Motor & Drives: Modeling, Analysis and Control, Prentice hall of India,2001, 1st Edition.

MAPPING COS AND POS:																
COs	**POs**												**PSOs**			
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO1 0**	**PO1 1**	**PO1 2**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**
CO1	2	2	2	2	2	1	-	-	-	-	-	1	3	3	1	2
CO2	2	2	2	2	2	1	-	-	-	-	-	1	3	3	1	2
CO3	2	3	3	2	2	1	-	-	-	-	-	1	3	3	1	2
CO4	2	2	1	2	3	1	-	-	-	-	-	1	3	3	1	2
CO5	1	3	3	2	2	1	-	-	-	-	-	1	3	3	1	2
Avg	1.8	2.4	2.2	2	2.2	1	-	-	-	-	-	1	3	3	1	2

EE23013	SMPS AND UPS	L	T	P	C
		3	0	0	3

UNIT I POWER CONDITIONERS AND UPS 9

Introduction – Power line disturbances – Power conditioners – UPS: Offline and On-line – Need for filters – Filter for PWM VSI – Front-end battery charger – boost charger.

UNIT II ANALYSIS OF NON-ISOLATED DC-DC CONVERTERS 9

Basic topologies: Buck, Boost and Buck-Boost - Principles of operation – Continuous conduction mode– Concepts of volt-sec balance and charge balance – Analysis and design based on steady-state relationships – Introduction to discontinuous conduction mode.

UNIT III ANALYSIS OF ISOLATED DC-DC CONVERTERS 9

Introduction - classification- forward- flyback- pushpull – half bridge – full bridge topologies- C'uk converter as cascade combination of boost followed by buck - design of SMPS — Introduction to design of magnetic components for SMPS using relevant software.

UNIT IV CONVERTER MODELLING 9

AC equivalent circuit analysis – State space averaging – Circuit averaging – Transfer function model for buck, boost and buck-boost converters.

UNIT V CONTROLLER DESIGN 9

Review of P, PI, and PID control concepts – gain margin and phase margin – Bode plot based analysis – Design of controller for buck converter and boost converter.

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/ Mini Project / Assignment/ Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc)

1. Simulation of Basic topologies.
2. Simulation of bidirectional DC DC converter (both non-isolated and isolated)considering EV as an example application.
3. Simulation of basic topologies using state space model derived – Comparison withthe circuit model based simulation already carried out.
4. Simulation study of controller design for basic topologies.
5. Simulation of battery charger for EV applications.

TOTAL:45 PERIODS

COURSE OUTCOMES:

After completion the above subject, students will be able to

CO1 understand the working of buck boost and buck-boost converters in continuous and discontinuous conduction mode.

CO2 build buck/boost converters using suitable design method.

CO3 Analyze the behaviors of isolated DC-DC converters and to design SMPS for battery operated vehicle.

CO4 compute state space averaged model and transfer function for buck, boost and buck-boost converters.

CO5 comprehend the P, PI and PID controller performance analytically and by simulation for buck boost and buck- boost converters

CO6 compare the different topologies of UPS and also simulate them.

TEXT BOOKS:

1. Robert W. Erickson & Dragon Maksimovic, " Fundamentals of Power Electronics", Third Edition, 2020
2. Ned Mohan," Power Electronics: A First Course", Johnwiley, 2013.
3. Marian K. Kazimierczuk and Agasthya Ayachit,"Laboratory Manual for Pulse-Width ModulatedDC–DC Power Converters", Wiley 2016.

REFERENCES:

1. Power Electronics handbook, Industrial Electronics series, S.K.Varenina, CRC press, 2002.
2. Power Electronic Converters, Teuvo Suntio, Tuomas Messo, Joonas Puukko, First Edition2017.

MAPPING COS AND POS:																
COs	**POs**												**PSOs**			
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO1 0**	**PO1 1**	**PO1 2**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**
CO1	2	2	3	2	2	1	-	-	-	-	-	1	3	3	1	3
CO2	2	2	3	3	3	1	-	-	-	-	-	1	3	3	1	3
CO3	2	2	2	3	2	2	-	-	-	-	-	1	3	3	2	3
CO4	1	2	3	3	3	1	-	-	-	-	-	1	3	3	2	3
CO5	2	2	2	3	2	1	-	-	-	-	-	1	3	3	1	2
CO6	1	2	2	2	2	2	-	-	-	-	-	1	3	3	1	2
Avg	1.6	2	2.5	2.6	2.3	1.3	-	-	-	-	-	1	3	3	1.3	2.6

EE23014		L	T	P	C
	POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS	**3**	**0**	**0**	**3**

UNIT I INTRODUCTION TO RENEWABLE ENERGY SYSTEMS 9

Introduction- Impacts of renewable energy generation on the environment – GHG effect, Qualitative study of renewable energy resources: Ocean, Biomass, Geothermal, Hydrogen energy systems, Solar Photovoltaic (PV) system, Wind Energy system and Fuel cells-Operating Principles types, VI characteristics.

UNIT II POWER ELECTRONIC CONVERTERS FOR RENEWABLE ENERGY 9

Solar: Line commutated converters (inversion mode) - Boost and buck-boost converters.
Wind: Three phase AC voltage controllers- AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters, Grid Interactive Inverters- multi-source converter.

UNIT III SOLAR PHOTO VOLTAIC SYSTEMS 9

Introduction, Photo Voltaic (PV) effect, Solar Cell, Types, Equivalent circuit of PV cell, PV cell characteristics (I/V and P/V) for variation of insolation, temperature and shading effect, Standalone PV system, Grid connected PV system, Design of PV system-load calculation, array sizing, selection of converter/inverter, battery sizing.

UNIT IV WIND ENERGY CONVERSION SYSTEMS 9

Introduction, Power contained in wind, Efficiency limit in wind, types of wind turbines, Wind control strategies, Power curve and Operating area, Types of wind generators system based on Electrical Machines-Induction Generator and Permanent Magnet Synchronous Generator (PMSG), Grid Connected- Self-excited operation of Induction Generator and Variable Speed PMSG.

UNIT V HYBRID RENEWABLE ENERGY SYSTEMS 9

Energy Storage systems, Need for Hybrid Systems- Range and type of Hybrid systems- Case studies of Diesel-PV, Wind-Diesel, Wind-PV, Maximum Power Point Tracking (MPPT) algorithms.

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc)

1. Simulation on modelling of Solar PV System- V I Characteristics
2. Simulation on Modelling of fuel cell- V I Characteristics
3. Simulation of self- excited Induction Generator.
4. Simulation of DFIG/ PMSG based Wind turbine.
5. Simulation on Grid integration of RES.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

After completion the above subject, students will be able to

CO1 To understand the various renewable energy sources and its impact.
CO2 To analyse the operation of electrical machines for wind energy conversion system.
CO3 To design solar PV systems.
CO4 To understand hybrid renewable energy systems and MPPT algorithm.
CO5 To analyse various power electronic converters for renewable energy systems.

REFERENCES:

1. S.N.Bhadra, D. Kastha, & S. Banerjee “Wind Electrical Systems”, Oxford University Press, 2009, 7th impression.
2. Rashid .M. H “Power electronics Hand book”, Academic press,2nd Edition, 2006 4th Edition, 2017
3. Rai. G.D, “Non-conventional energy sources”, Khanna publishers, 6th Edition, 2017.
4. Rai. G.D,” Solar energy utilization”, Khanna publishers, 5th Edition, 2008.
5. Gray, L. Johnson, “Wind energy system”, prentice hall of india, 2nd Edition, 2006.
6. H.Khan "Non-conventional Energy sources ",Tata McGraw-hill Publishing Company, New Delhi, 2017, 3rd Edition.

MAPPING COS AND POS:

COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	1	2	1	2	2	2	3	-	-	-	-	1	3	3	2	3
CO2	2	2	2	2	2	1	3	-	-	-	-	1	3	3	2	3
CO3	1	2	2	2	2	2	3	-	-	-	-	1	3	3	2	3
CO4	1	2	1	2	2	2	3	-	-	-	-	1	3	3	2	3
CO5	2	2	3	2	3	1	3	-	-	-	-	1	3	3	2	3
Avg	1.4	2	1.8	2	2.2	1.6	3	-	-	-	-	1	3	3	2	3

EE23015	CONTROL OF POWER ELECTRONICS CIRCUITS	L	T	P	C
		3	0	0	3

UNIT I REVIEW OF CONTROL SYSTEM BASICS 9

Time Domain Analysis-Frequency System Analysis-Stat Space Analysis-Transfer Function Model of Power Converters.

UNIT II P,PI and PID CONTROLLERS 9

Design of P and PI Controller for First order plant – Need for Integral Component – Second order plant and Effect derivative component- Effect of RHP zero on the performance.

UNIT III SLIDING MODE CONTROL BASICS 9

Introduction- Introduction to Sliding-Mode Control- Basics of Sliding-Mode Theory- Application of Sliding-Mode Control to DC-DC Converters—Principle-Sliding mode control of buck converter.

UNIT IV POWER FACTOR CORRECTION CIRCUITS 9

Introduction, Operating Principle of Single-Phase PFCs, Control of boost converter based PFCs, Designing the Inner Average-Current-Control Loop, Designing the Outer Voltage-Control Loop, Example of Single-Phase PFC Systems- Power Factor Correction circuit using other topologies: CUK and SEPIC Converters-PFC circuits employing bridgeless topologies.

UNIT V INTELLIGENT CONTROLLERS 9

Introduction to Fuzzy and Neuro Controllers – Usage with Power Converter Applications

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/ Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc)

1. Simulation exercises on zero, first and second order basic blocks.
2. Design of classical P, PI, PID controller with the help of suitable simulation and software.
3. Simulation of Sliding mode control based buck converter.
4. Simulation of Single-Phase PFC circuit employing boost converter.
5. Simulation of Single-Phase PFC circuit employing Cuk converters

TOTAL: 45 PERIODS

COURSE OUTCOMES:

After completion the above subject, students will be able to

- **CO1** calculate transfer function for constant, differential, integral, First order and Second order factors.
- **CO2** illustrate the effect of poles and zero's in the 's' plane.
- **CO3** select Symbolic equations for solving problems related with Matrices, Polynomial and vectors.
- **CO4** compute the control expression for DC – DC buck converter using sliding mode control theory.
- **CO5** determine the controller expression for power factor correction circuits.
- **CO6** simulate sliding mode control of buck converter and power factor correction circuit.

TEXT BOOKS:

1. Feedback Control problems using MATLAB and the Control system tool box By DeanFrederick and Joe Chow, 2000, 1st Edition, Cengage Learning.
2. Ned Mohan,"Power Electronics: A First Course", Johnwiley, 2013, 1st Edition.

3. Marian K. Kazimierczuk and AgasthyaAyachit,"Laboratory Manual for Pulse-WidthModulated DC-DC Power Converters", Wiley 2016, 1st Edition.
4. Power Electronics handbook, Industrial Electronics series, S.K.Varenina, CRC press, 2002,1st Edition.

REFERENCES:

1. Sliding mode control for Switching Power Converters:, Techniques and Implementation, Slew-Chong Tan, Yuk Ming Lai Chi-Kong Tse, 1st Edition, CRC Press.
2. Andre Kislovski, "Dynamic Analysis of Switching-Mode DC/DC Converters", Springer 1991.
3. MATLAB Symbolic Algebra and Calculus Tools, Lopez Cesar, Apress, 2014.

MAPPING COS AND POS:

COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	2	2	2	2	2	2	-	-	-	-	-	1	3	3	1	3
CO2	2	2	1	2	2	1	-	-	-	-	-	1	3	3	1	2
CO3	2	2	2	2	2	1	-	-	-	-	-	1	3	3	2	2
CO4	3	2	2	3	2	1	-	-	-	-	-	1	3	3	2	2
CO5	2	2	2	3	3	2	-	-	-	-	-	1	3	3	2	2
CO6	2	2	2	2	3	2	-	-	-	-	-	1	3	2	2	2
Avg	2.2	2	1.8	2.3	2.3	1.5	-	-	-	-	-	1	3	2.8	1.6	2.2

EE23016	POWER QUALITY	L	T	P	C
		3	0	0	3

UNIT I INTRODUCTION TO POWER QUALITY 9

Terms and definitions – Overloading, under voltage, over voltage - Concepts of transients - Short duration variations such as interruption - Long duration variation such as sustained interruption - Voltage sag - Voltage swell - Voltage imbalance – Voltage fluctuation - Power frequency variations - International standards of power quality – Computer Business Equipment Manufacturers Associations (CBEMA) curve.

UNIT II VOLTAGE SAGS AND INTERRUPTIONS 9

Sources of sags and interruptions - Estimating voltage sag performance - Thevenin's equivalent source - Analysis and calculation of various faulted condition - 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.

UNIT III OVERVOLTAGES & HARMONICS 9

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 - Harmonics Vs transients. Effect of harmonics – Harmonic distortion - Voltage and current distortion - Harmonic indices - Devices for controlling harmonic distortion - Passive and active filters.

UNIT IV POWER QUALITY MONITORING 9

Monitoring considerations - Monitoring and diagnostic techniques for various power quality problems - Modeling of power quality (harmonics and voltage sag) problems by mathematical simulation tools - Power line disturbance analyzer – Quality measurement equipment - Harmonic / spectrum analyzer - Flicker meters - Disturbance analyzer.

UNIT V POWER QUALITY MITIGATION 9

Conventional load Compensation methods: Harmonic reduction & Voltage Sag reduction – Analysis of Unbalance – Load compensation using DSTATCOM: Ideal 3-phase Shunt Compensation structure, Reference current generation, realization and control of DSTATCOM – Introduction to series compensation using DVR.

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc)

1. Harmonic analysis of single phase power converters (Semi converters and FullConverters) with R and RL load via simulation
2. Harmonic analysis of three phase power converters (Semi converters and FullConverters) with R and RL load via simulation
3. Harmonic analysis of single phase inverters with R and RL load via simulation
4. Harmonic analysis of three phase inverters with R and RL load via simulation
5. Mitigation of Harmonics using Tuned Filter

TOTAL: 45 PERIODS

COURSE OUTCOMES:

After completion the above subject, students will be able to

CO1 Comprehend the Basics of Power Quality issues and their Standards.
CO2 Understand the concepts of Sag and Swell problems.
CO3 Appreciate the harmonic problems and understand the enhancement methods.
CO4 Analyze the Power Quality problems and understand the monitoring Instruments.
CO5 Understand the mitigation methods including conventional compensation and modern techniques like usage of DSTATCOM and DVR.

TEXT BOOKS:

1. Roger. C. Dugan, Mark. F. McGranagham, Surya Santoso, H.Wayne Beaty, “Electrical Power Systems Quality”, McGraw Hill,2003.
2. J. Arrillaga, N.R. Watson, S. Chen, “Power System Quality Assessment”, (New York: Wiley, 1999).

REFERENCES:

1. G.T. Heydt, “Electric Power Quality”, 2nd Edition. (West Lafayette, IN, Stars in a Circle Publications, 1994).
2. M.H.J Bollen, “Understanding Power Quality Problems: Voltage Sags and Interruptions”, (New York: IEEE Press, 1999).
3. Arindhan Ghosh, “Power Quality Enhancement using custom Power Devices, Kluwer Academic Publishers,2002

List of Open Source Software/ Learning website:

1. http://nptel.iitm.ac.in/courses.php
2. https://old.amu.ac.in/emp/studym/2442.pdf
3. https://electricalacademia.com/electric-power
4. https://www.intechopen.com/books/6214
5. https://www.cde.com/resources/technical-papers/Mitigation-of-Harmonics.pdf
6. https://www.academia.edu/43237017/Use_Series_Compensation_in_Distribution_Networks_33_KV

MAPPING COS AND POS:

COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	1	1	1	1	1	1	-	1	-	-	-	-	2	2	1	1
CO2	1	1	1	1	1	1	-	-	-	-	-	-	2	2	1	1
CO3	1	1	1	1	1	1	-	-	-	-	-	-	2	2	1	1
CO4	1	2	2	3	3	3	-	-	-	-	-	-	2	2	3	1
CO5	1	3	3	3	1	3	1	1	-	-	-	-	2	2	3	3
Avg	1	1.6	1.6	1.8	1.4	1	1	1	-	-	-	-	2	2	1.8	1.4

VERTICAL III: EMBEDDED SYSTEMS

		L	T	P	C
EE23017	**EMBEDDED C- PROGRAMMING**	**3**	**0**	**0**	**3**

UNIT I BASIC C PROGRAMMING 9

Typical C Program Development Environment - Introduction to C Programming - Structured Program Development in C - Data Types and Operators - C Program Control - C Functions - Introduction to Arrays.

UNIT II EMBEDDED C 9

Adding Structure to 'C' Code: Object-oriented programming with C, Header files for Project and Port, Examples. Meeting Real-time constraints: Creating hardware delays - Need for timeout mechanism - Creating loop timeouts - Creating hardware timeouts.

UNIT III 8051 Programming in C 9

Data types and time delay in 8051, I/O programming in 8051, Logic operations in 8051, Data conversion program in 8051 Accessing code ROM space in 8051, Data serialization using 8051.

UNIT IV 8051 SERIAL PORT AND INTERRUPT PROGRAMMING IN C 9

Basics of serial communication, 8051 interface to RS232- serial port programming in 8051. 8051 interrupts and programming, Programming for timer configuration.

UNIT V 8051 INTERFACING 9

8051: ADC interfacing, DAC interfacing, Sensor interfacing, LCD interfacing, Stepper motor interfacing.

SKILL DEVELOPMENT ACTIVITIES (Group Seminar /Mini Project /Assignment / Content Preparation / Quiz/ Surprise Test / etc)

1. Laboratory exercise: Use 8051 microcontroller/Embedded processor/IDE/open sourceplatform to give hands-on training on Embedded C- programming.
   a. Introduction to IDE (like code blocks, vscode ,etc)and Programming Environment (likeKeililu vision, Proteus)
   b. Configuring an I/O port using bitwise programming.
   c. Configuring timer for generating hardware delay.
   d. Flashing an LED using an interrupt
   e. Serial communication using UART port of 8051
   f. Interfacing an ADC with 8051
   g. Interfacing an analog sensor with 8051
   h. Interfacing 16x2 LCD and keypad interface with 8051
   i. configuring timer for generating PWM signal
   j. Interfacing a stepper motor with 8051
2. Assignment: Introduction to Arduino IDE, Raspberry Pi
3. Embedded C-Programming -based Mini project.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1 Deliver insight into embedded C programming and its salient features for embedded systems.

CO2 Illustrate the software and hardware architecture for distributed computing in embedded systems.

CO3 Develop a solution for problems by using the concept learned in programming using the embedded controllers.

CO4 Develop simple applications with 8051 by using its various features and interfacing with various external hardware.

CO5 Improved Employability and entrepreneurship capacity due to knowledge upgradation on recent trends in embedded programming skills.

TEXT BOOKS:

1. Paul Deitel and Harvey Deitel, “C How to Program”, 9th Edition, Pearson EducationLimited, 2022, 1st edition.
2. Michael J Pont, "Embedded C", Addison-Wesley, An imprint of Pearson Education, 2002.
3. William von Hagen, "The Definitive Guide to GCC", 2nd Edition, Apress Inc., 2006.
4. Gowrishankar S and Veena A, "Introduction to Python Programming", CRC Press, Taylor & Francis Group, 2019

REFERENCES:

1. Noel Kalicharan, "Learn to Program with C", Apress Inc., 2015, 1st edition.
2. Steve Oualline, "Practical C programming", O'Reilly Media, 1997, 3rd edition.
3. Muhammad Ali Mazidi, Janice G. Mazidi and Rolin D. McKinlay, ‘The 8051Microcontroller and Embedded Systems’ Prentice Hall, 2nd Edition 2007.
4. Myke Predko, “Programming and customizing the 8051 microcontrollers”, McGrawwHill 2000, 1st edition.

List of Open Source Software/ Learning websites:

1 https://www.hackerrank.com/
2 https://www.cprogramming.com/
3 https://www.allaboutcircuits.com/technical-articles/introduction-to-the-c-programming-language-for-embedded-applications/
4 https://onlinecourses.nptel.ac.in/noc19_cs42/preview
5 https://microcontrollerslab.com/8051-microcontroller-tutorials-c/
6 https://www.circuitstoday.com/getting-started-with-keil-uvision

MAPPING COS AND POS:

COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	3	2	2	3	-	-	-	1	-	1	2	1	2	1	3
CO2	2	2	2	3	2	-	-	-	1	-	1	1	1	2	2	2
CO3	3	1	2	1	1	-	-	-	1	-	1	2	1	1	1	2
CO4	2	3	3	1	1	-	-	-	1	-	1	2	1	2	1	3
CO5	2	2	2	3	2	-	-	-	1	-	1	1	1	2	1	3
Avg	2.4	2.2	2.2	2	1.8	-	-	-	1	-	1	1.6	1	1.8	1.2	2.6

EE23018	EMBEDDED PROCESSORS	L	T	P	C
		3	0	0	3

UNIT I ARM ARCHITECTURE 9

Architecture – Memory Organization – addressing modes -Registers – Pipeline - Interrupts – Coprocessors — Interrupt Structure.

UNIT II ARM MICROCONTROLLER PROGRAMMING 9

ARM general Instruction set — Thumb instruction set –Introduction to DSP on ARM- basic programming.

UNIT III PERIPHERALS OF ARM 9

ARM: I/O Memory – EEPROM – I/O Ports – SRAM –Timer –UART - Serial Communication with PC – ADC/DAC Interfacing-stepper motor interfacing.

UNIT IV ARM COMMUNICATION 9

ARM With CAN, I^2C, and SPI protocols.

UNIT V INTRODUCTION TO SINGLE BOARD EMBEDDED PROCESSOR 9

Raspberry Pi Architecture - Booting Up RPi- Operating System and Linux Commands -Working with RPi using Python and Sensing Data using Python-programming - GPIO and interfacing peripherals With Raspberry Pi.

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / etc)

1. Laboratory exercise:
   a) Programming with IDE - ARM microcontroller
   b) Advanced Timer Features, PWM Generator.
   c) RTC interfacing with ARM using Serial communication programming, Stepper motor control.
   d) ARM-Based Wireless Environmental Parameter Monitoring System displayed through Mobile device.
2. Seminar:
   a) ARM and GSM/GPS interfacing
   b) Introduction to ARM Cortex Processor
3. Raspberry Pi based Mini project.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1 Interpret the basics and functionality of processor functional blocks.
CO2 Observe the specialty of RISC processor Architecture.
CO3 Incorporate the I/O hardware interface of processor with peripherals.
CO4 Emphasis the communication features of the processor.
CO5 Improved Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in commercial embedded processors.

TEXT BOOKS:

1. Steve Furber, 'ARM system on chip architecture',Addisonn Wesley,2nd Edition,2015.
2. Andrew N. Sloss, Dominic Symes, Chris Wright, John Rayfield's ARM System Developer's Guide Designing and Optimizing System Software', Elsevier 2004, 1st Edition.

REFERENCES:

1. William Hohl, ' ARMAssebly Language' Fundamentals and Techniques, CRC Press, 2nd Edition 2014.
2. Rajkamal," Microcontrollers Architecture, Programming, Interfacing, & System Design, Pearson,2012, 2nd Edition.
3. ARM Architecture Reference Manual, LPC214x User Manual www.Nuvoton .com/websites on Advanced ARM Cortex Processors
4. ARM System Developer's Guide: Designing and Optimizing System Software 1st Edition (Designing and Optimizing System Software) Publisher: Morgan Kaufmann Publishers, 2011.

List of Open Source Software/ Learning websites:

1. https://nptel.ac.in/courses/117106111
2. https://onlinecourses.nptel.ac.in/noc20_cs15/preview
3. https://www.csie.ntu.edu.tw/~cyy/courses/assembly/12fall/lectures/handouts/lec08_ARMarch.pdf
4. https://maxembedded.com/2013/07/introduction-to-single-board-computing/
5. https://www.youtube.com/watch?v=J4fhE4Pp55E&list=PLGs0VKk2DiYypuwUUM2wxzcI9BJHK4Bfh

MAPPING COS AND POS:																
COs	**POs**												**PSOs**			
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**
CO1	3	3	2	2	3	-	-	-	1	-	1	2	3	3	2	1
CO2	2	2	3	2	2	-	-	-	1	-	1	2	2	3	2	2
CO3	2	3	1	2	1	-	-	-	1	-	1	1	1	1	1	2
CO4	3	2	1	1	2	-	-	-	1	-	1	1	1	2	1	1
CO5	2	1	2	3	3	-	-	-	1	-	1	1	2	2	1	3
Avg	2.4	2.2	1.8	2	2.2	-	-	-	1	-	1	1.3	1.8	2.2	1.4	1.8

EE23019	EMBEDDED CONTROL FOR ELECTRIC DRIVES	L	T	P	C
		3	0	0	3

UNIT I INTRODUCTION TO ELECTRIC DRIVES 9

Electric drives and its classification-Four-quadrant drive-Solid State Controlled Drives-Machine learning and optimization techniques for electrical drives.

UNIT II EMBEDDED SYSTEM FOR MOTOR CONTROL 9

Embedded Processors choice for motor control- Sensors and interface modules for Electric drives-IoT for Electrical drives applications.

UNIT III INDUCTION MOTOR CONTROL 9

Speed control methods-PWM techniques- VSI fed three-phase induction motor- Fuzzy logic Based speed control for three-phase induction motor- Embedded processor based three phase induction motor speed control.

UNIT IV BLDC MOTOR CONTROL 9

Overview of BLDC Motor -Speed control methods -PWM techniques- Embedded processor based BLDC motor speed control.

UNIT V SRM MOTOR CONTROL 9

Overview of SRM Motor -Speed control methods -PWM techniques- Embedded processor based SRM motor speed control.

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / etc)

1. Laboratory exercise: Use any System level simulator/MATLAB/open source platform to give hands-on training on simulation study on Electric drives and control.
   a. Simulation of four quadrant operation and speed control of DC motor
   b. Simulation of 3-phase inverter.
   c. Simulation of Speed control of Induction motor using any suitable software package.
   d. Simulation of Speed control of BLDC motor using any suitable software package.
   e. Simulation of Speed control of SRM using any suitable software package
3. Seminar: IoT-based Control and Monitoring for DC Motor/ any Electric drives.
4. Mini project.: Any Suitable Embedded processor-based speed control of Motors (DC/IM/BLDC/PMSM/SRM)

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1 Interpret the significance of embedded control of electrical drives.
CO2 Deliver insight into various control strategies for electrical drives.
CO3 Developing knowledge of Machine learning and optimization techniques for motor control.
CO4 Develop embedded system solutions for real-time application such as Electric vehicles and UAVs.
CO5 Improved Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in embedded system skills required for motor control strategy.

TEXT BOOKS:

1. R.Krishnan, “Electric Motor Drives – Modeling, Analysis and Control”,Prentice-Hall of India Pvt. Ltd., New Delhi,2010, 1st Edition.
2. Steve Kilts, "Advanced FPGA Design: Architecture, Implementation, and Optimization"Willey, 2007, 1st Edition.

REFERENCES:

1. VedamSubramanyam, “Electric Drives – Concepts and Applications”, Tata McGraw- Hill publishing company Ltd., New Delhi, 2002, 2nd Edition.
2. K. Venkataratnam ,Special Electrical Machines, Universities Press, 2014, 1st Edition.
3. Steve Furber, ‘ARM system on chip architecture’, Addision Wesley, 2nd Edition 2015.
4. Ron Sass and AnderewG.Schmidt, “ Embedded System design with platform FPGAs: Principles and Practices”, Elsevier, 2010, 1st Edition.
5. Tim Wescott , Applied Control Theory for Embedded Systems **,** Elsevier, 2006, 1st Edition.

List of Open Source Software/ Learning website:

1. https://archive.nptel.ac.in/courses/108/104/108104140/
2. https://www.embedded.com/mcus-or-dsps-which-is-in-motor-control/
3. https://www.e3sconferences.org/articles/e3sconf/pdf/2019/13/e3sconf SeFet2019_01004.pdf
4. https://www.electronics-tutorials.ws/blog/pulse-width-modulation.html
5. http://kaliasgoldmedal.yolasite.com/resources/SEM/SRM.pdf

MAPPING COS AND POS:

COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	2	3	2	2	2	-	1	-	1	-	1	1	3	2	1	1
CO2	3	3	1	1	1	-	1	-	1	-	1	1	3	3	1	1
CO3	2	2	1	1	3	-	1	-	1	-	1	1	3	3	1	1
CO4	2	2	2	1	2	-	1	-	1	-	1	1	3	3	1	2
CO5	2	2	1	1	3	-	1	-	1	-	1	1	3	3	1	2
Avg	2.2	2.4	1.4	1.2	2.2	-	1	-	1	-	1	1	3	2.8	1	1.4

EE23020	SMART SYSTEM AUTOMATION	L	T	P	C
		3	0	0	3

UNIT I INTRODUCTION 9

Overview of a smart system - Hardware and software selection - Smart sensors and Actuators – Communication protocols used for smart systems.

UNIT II HOME AUTOMATION 9

Home Automation – System Architecture - Essential Components - Design Considerations: Control Unit, Sensing Requirements, Communication, Data Security.

UNIT III SMART APPLIANCES AND ENERGY MANAGEMENT 9

Significance of smart appliances for energy management -Smart Meters: Significance, Architecture& Energy Measurement Technique — Security Considerations.

UNIT IV SMART WEARABLE DEVICES 9

Body Area Networks - Sensors– communication protocol for Wearable devices- Application of Smart Wearable in Healthcare & Activity Monitoring.

UNIT V EMBEDDED SYSTEMS AND ROBOTICS 9

Fundamental concepts in Robotics- Robots and Controllers components - Embedded processor based: pick and place robot- Mobile Robot Design- UAV.

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / etc)

1. Laboratory exercise: Use Arduino/ R pi/ any other Embedded processors to givehands on training to understand concepts related to smart automation.
   a. Hands on experiments based on Ubidots & Thing speak / Open-source AnalyticsPlatform
   b. Design and implementation of a smart home system.
   c. Bluetooth Based Home Automation Project using Android Phone
   d. GSM Based Home Devices Control
   e. Pick and place robots using Arduino/ any suitable Embedded processor
2. Assignment: Revolution of Smart Automation system across the world and itscurrent scope available in India
3. Mini project: Design of a Smart Automation system (for any application of student's choice)

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1 Understand the concepts of smart system design and its present developments.
CO2 Illustrate different embedded open-source and cost-effective techniques for developing solution for real time applications.
CO3 Acquire knowledge on different platforms and Infrastructure for Smart system design.
CO4 Infer about smart appliances and energy management concepts.
CO5 Improve Employability and entrepreneurship capacity due to knowledge upgradation on embedded system technologies.

TEXT BOOKS:

1. Grimm, Christoph, Neumann, Peter, Mahlknech and Stefan, Embedded Systems forSmart Appliances and Energy Management, Springer 2013, 1st Edition.
2. KazemSohraby, Daniel Minoli and TaiebZnati, Wireless Sensor Networks Technology, Protocols, and Applications, John Wiley & Sons, 2007, 1st Edition.
3. NilanjanDey, Amartya Mukherjee, Embedded Systems and Robotics with Open-SourceTools, CRC press, 2016, 1st Edition.

REFERENCES:

1. Thomas Bräunl, Embedded Robotics, Springer, 2003.
2. Raj Kamal, Embedded Systems - Architecture, Programming and Design, McGraw- Hill,2008
3. Karim Yaghmour, Embedded Android, O'Reilly, 2013.
4. Steven Goodwin, Smart Home Automation with Linux and Raspberry Pi, Apress , 2013
5. C.K. Toh, AdHoc mobile wireless networks, Prentice Hall, Inc, 2002.
6. Anna Ha´c, Wireless Sensor Network Designs, John Wiley & Sons Ltd, 2003.
7. J. J. Craig, “Introduction to Robotics Mechanics and Control”, Pearson Education.
8. Y. Koren, “Robotics for Engineers”, McGraw-Hill.
9. Robert Faludi, Wireless Sensor Networks, O’Reilly, 2011.

List of Open Source Software/ Learning website:

1. https://microcontrollerslab.com/home-automation-projects-ideas/
2. https://www.learnrobotics.org/blog/simple-robot/
3. https://robolabor.ee/homelab/en/iot
4. https://electrovolt.ir/wp-content/uploads/2018/03/ExploringRaspberryPiMolloyDerekElectroVolt.ir.pdf
5. http://www.robot.bmstu.ru/files/books/(Ebook%20-%20English)%20Mcgraw-Hil,%20Pic%20Robotics%20--%20A%20Beginner'S%20Guide%20To%20Robotic.pdf

MAPPING COS AND POS:

COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	3	2	2	3	1	1	-	1	-	1	2	3	3	2	1
CO2	2	2	3	2	2	1	1	-	1	-	1	2	2	3	2	2
CO3	2	3	1	2	1	1	1	-	1	-	1	1	1	1	1	2
CO4	3	2	1	1	2	1	1	-	1	-	1	1	1	2	1	1
CO5	2	1	2	3	3	1	1	-	1	-	1	1	2	2	1	3
Avg	2.4	2.2	1.8	2	2.2	1	1	-	1	-	1	1.3	1.8	2.2	1.4	1.8

EE23021	EMBEDDED SYSTEM FOR AUTOMOTIVE APPLICATIONS	L	T	P	C
		3	0	0	3

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.

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,ETHERNET and MOST.

UNIT V RECENT TRENDS 9

Navigation- Autonomous car- Role of IoT in Automotive systems.

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / etc)

1. Laboratory exercise:Use MATLAB SIMULINK /equivalent simulation /open source tools
   a. Simulation study of automotive sensors and actuators components.
   b. Adaptive cruise control, Anti-Lock Braking System.
   c. CAN Connectivity in an Automotive Application using vehicle network toolbox.
   d. Interfacing a sensor used in car with microcontroller.
   e. Establishing connection between Bluetooth module and microcontroller.
2. Assignment: AUTOSAR
3. Mini project : Battery Management system for EV batteries

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1 Insight into the significance of the role of embedded system for automotive applications.
CO2 Illustrate the need, selection of sensors and actuators and interfacing with ECU.
CO3 Develop the Embedded concepts for vehicle management and control systems.
CO4 Demonstrate the need of Electrical vehicle and able to apply the embedded system technology for various aspects of EVs.
CO5 Improved Employability and entrepreneurship capacity due to knowledge up gradation onrecent trends in embedded systems design and its application in automotive systems.

TEXT BOOKS:

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.

REFERENCES:

1. Ali Emedi, Mehrdedehsani, John M Miller , “Vehicular Electric power system- land, Sea, Airand 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, andVehicle”, Springer; 1st Edition, 2005.
6. Automotive Electricals Electronics System and Components, Robert Bosch Gmbh, 5th Edition 2014.
7. Automotive Hand Book, Robert Bosch, Bently Publishers, 10th Edition, 2018.

List of Open Source Software/ Learning website:

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://prodigytechno.com/difference-between-lin-can-and-flexray-protocols/
6. https://www.synopsys.com/automotive/what-is-autonomous-car.html

MAPPING COS AND POS:

COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	3	2	2	3	-	1	-	1	1	1	2	3	3	2	1
CO2	2	2	3	2	2	-	1	-	1	1	1	2	2	3	2	2
CO3	2	3	1	2	1	-	1	-	1	1	1	1	1	1	1	2
CO4	3	2	1	1	2	-	1	-	1	1	1	1	1	2	1	1
CO5	2	1	2	3	3	-	1	-	1	1	1	1	2	2	1	3
Avg	2.4	2.2	1.8	2	2.2	-	1	-	1	1	1	1.3	1.8	2.2	1.4	1.8

EE23022	VLSI DESIGN	L	T	P	C
		3	0	0	3

UNIT I CMOS BASICS **9**

MOSFET Scaling - CMOS logic design- Dynamic CMOS –Transmission Gates- BiCMOS.

UNIT II IC FABRICATION **9**

CMOS IC Fabrications: n well, p well, twin tub, SoI - Design Rules and Layout.

UNIT III PROGRAMABLE LOGIC DEVICES **9**

PAL, PLA, CPLD architecture and application.

UNIT IV RECONFIGURABLE PROCESSOR **9**

FPGA- Architecture, FPGA based application development- Introduction to FPAA.

UNIT V HDL PROGRAMMING **9**

Verilog HDL- Overview - structural and behavioural modeling concepts-Design examples- Carry Look ahead adders, ALU, Shift Registers.

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / etc)

1. Laboratory exercise : Use any FPGA Board /IDE/open source package/ platform to give hands on training on CMOS design/ reconfigurable processor based applications,
   a. CMOS logic circuit simulation using any open source software package
   b. Experiments : structural and behavioural modeling based Verilog HDL programs
   c. Experiment: Combinational and sequential Digital logic implementation withFPGA.
   d. Implementation of carry look ahead adder with FPGA
   e. Implementation of ALU with FPGA
2. Assignment : Low Power VLSI.
3. FPGA based Mini project.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1 Develop CMOS design techniques.
CO2 Learn and build IC fabrication.
CO3 Explain the need of reconfigurable computing with PLDs.
CO4 Design and development of reprogrammable FPGA.
CO5 Illustrate and develop HDL computational processes with improved design strategies.

TEXT BOOKS:

1. M.J.S Smith, “Application Specific integrated circuits”,Addition Wesley Longman Inc. 1st Edition 2010.
2. Kamran Eshraghian, Douglas A.pucknell and Sholeh Eshraghian,”Essentials of VLSI circuits andsystem”, Prentice Hall India,2005, 1st Edition.

REFERENCES:

1. Donald G. Givone, “Digital principles and Design”, Tata McGraw Hill 2002, 1st Edition.
2. Charles H. Roth Jr., “Fundamentals of Logic design”, Thomson Learning, 7th Edition 2013.
3. Nurmi, Jari (Ed.) "Processor Design System-On-Chip Computing for ASICs and FPGAs" Springer, 2007, 1st Edition.
4. Joao Cardoso, Michael Hübner, "Reconfigurable Computing: From FPGAs to Hardware/Software Codesign" Springer, 2011, 1st Edition.
5. Pierre-Emmanuel Gaillardon, Reconfigurable Logic: Architecture, Tools, and Applications,1st Edition, CRC Press , 2018.

List of Open Source Software/ Learning website:

1. https://archive.nptel.ac.in/courses/108/107/108107129/
2. http://gn.dronacharya.info/ ECEDept/Downloads/QuestionPapers/ 7th_Sem/VLSI-DESIGN/UNIT-1/Lecture-3.pdf
3. https://web.itu.edu.tr/~ateserd/vlsi2/2007/FPGAs&CPLD.pdf
4. https://kanchiuniv.ac.in/coursematerials/GSK_Notes_on_PLD_in_VLSI_design.pdf
5. https://www.xilinx.com/products/silicon-devices/resources/programming-an-fpga-an-introduction-to-how-it-works.html
6. https://www.allaboutcircuits.com/technical-articles/what-is-an-fpga-introduction-to-programmable-logic-fpga-vs-microcontroller/
7. https://www.tutorialspoint.com/vlsi_design/vlsi_design_vhdl_introduction.htm#:~:text=VHDL%20stands%20for%20very%20high,DoD)%20under%20the%20VHSIC%20program

MAPPING COS AND POS:

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CO3	2	2	1	1	3	-	1	-	1	-	1	1	3	3	1	1
CO4	2	2	2	1	2	-	1	-	1	-	1	1	3	3	1	2
CO5	2	2	1	1	3	-	1	-	1	-	1	1	3	3	1	2
Avg	2.2	2.4	1.4	1.2	2.2	-	1	-	1	-	1	1	3	2.8	1	1.4

EE23023	DIGITAL SIGNAL PROCESSING	L	T	P	C
		3	0	0	3

UNIT I INTRODUCTION 9

Classification of systems: Continuous, discrete, linear, causal, stable, dynamic, recursive, time variance; classification of signals: continuous and discrete, energy and power; mathematical representation of signals; spectral density; sampling techniques, quantization, quantization error, Nyquist rate, aliasing effect. Digital signal representation.

UNIT II DISCRETE TIME SYSTEM ANALYSIS 9

Z-transform and its properties, inverse z-transforms; difference equation – Solution by z-transform, application to discrete systems - Stability analysis, frequency response – Convolution – Introduction to Fourier Transform– Discrete time Fourier transform.

UNIT III DISCRETE FOURIER TRANSFORM & COMPUTATION 9

DFT properties, magnitude and phase representation - Computation of DFT using FFT algorithm –DIT & DIF - FFT using radix 2 — Butterfly structure.

UNIT IV DESIGN OF DIGITAL FILTERS 9

FIR & IIR filter realization – Parallel & cascade forms. FIR design: Windowing Techniques – Need and choice of windows – Linear phase characteristics. IIR design: Analog filter design - Butterworthand Chebyshev approximations; digital design using impulse invariant and bilinear transformation -Warping, prewarping -Frequency transformation.

UNIT V DIGITAL SIGNAL PROCESSORS 9

Introduction – Architecture of one DSP processor for motor control – Features – Addressing Formats– Functional modes - Introduction to Commercial Processors.

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / etc)

1. Laboratory exercise : Use any DSP processor/MATLAB/open source platform to give hands on training on basic concepts of Digital Signal Processing
   a. To determine impulse and step response of two vectors
   b. To perform convolution between two vectors .
   c. To compute DFT and IDFT of a given sequence.
   d. To perform linear convolution of two sequence using DFT
   e. Design and Implementation of FIR Filter
   f. Design and Implementation of IIR Filter
   g. To determine z-transform from the given transfer function and its ROC
2. Assignment: Implementation of FIR/IIR filter with FPGA.
3. DSP processors based Mini project

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1 Explain the concepts of digital signal processing.
CO2 Illustrate the system representation using transforms.
CO3 Learn the transformation techniques for time to frequency conversion.
CO4 Design suitable digital FIR, IIR algorithm for the given specification.
CO5 Use digital signal processor for application development.

TEXT BOOKS:

1. J.G. Proakis and D.G. Manolakis, 'Digital Signal Processing Principles, Algorithms and Applications', Pearson Education, New Delhi, 4th Edition 2007.
2. Robert J.Schilling & Sandra L.Harris ,' Introduction to Digital Signal Processing using MATLAB', Cengage Learning, 2nd Edition 2013.

REFERENCES:

1. Emmanuel C Ifeachor and Barrie W Jervis ,"Digital Signal Processing – A Practical approach"Pearson Education, Second edition, 2002.
2. Alan V. Oppenheim, Ronald W. Schafer and John R. Buck, 'Discrete – Time Signal Processing',Pearson Education, New Delhi, 2nd Edition 2012.
3. SenM.kuo, Woonseng…s.gan, "Digital Signal Processors, Architecture, Implementations &Applications, Pearson, 1st Edition 2004.
4. S.K. Mitra, 'Digital Signal Processing – A Computer Based Approach', Tata McGraw Hill, NewDelhi, 4th Edition 2013.
5. B. Venkataramani, M. Bhaskar, 'Digital Signal Processors, Architecture, Programming and Applications', Tata McGraw Hill, New Delhi, 2003, 1st Edition.

List of Open Source Software/ Learning website:

1. https://nptel.ac.in/courses/117102060
2. https://www.tutorialspoint.com/digital_signal_processing/index.htm
3. https://www.elprocus.com/digital-signal-processor/
4. https://www.sciencedirect.com/topics/computer-science/digital-signal-processing-algorithm#:~:text=Digital%20signal%20processing%20algorithms%20are,known%20as%20operations%20or%20ops
5. https://www.electronicshub.org/introduction-to-fpga/

MAPPING COS AND POS:

COs	POs												PSOs			
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CO1	2	3	2	2	2	1	-	-	1	-	1	1	3	2	1	1
CO2	3	3	1	1	1	1	-	-	1	-	1	1	3	3	1	1
CO3	2	2	1	1	3	1	-	-	1	-	1	1	3	3	1	1
CO4	2	2	2	1	2	1	-	-	1	-	1	1	3	3	1	2
CO5	2	2	1	1	3	1	-	-	1	-	1	1	3	3	1	2
Avg	2.2	2.4	1.4	1.2	2.2	1	-	-	1	-	1	1	3	2.8	1	1.4

EE23024	BIG DATA ANALYTICS	L	T	P	C
		3	0	0	3

UNIT I UNDERSTANDING BIG DATA 9

Introduction to big data – convergence of key trends – unstructured data – industry examples of big data – web analytics – big data applications– big data technologies – introduction to Hadoop – open source technologies – cloud and big data – mobile business intelligence – Crowd sourcing analytics – inter and trans firewall analytics.

UNIT II NOSQL DATA MANAGEMENT 9

Introduction to NoSQL – aggregate data models – key-value and document data models – relationships – graph databases – schemaless databases – materialized views – distribution models – master-slave replication – consistency - Cassandra – Cassandra data model – Cassandra examples – Cassandra clients.

UNIT III MAP REDUCE APPLICATIONS 9

MapReduce workflows – unit tests with MRUnit – test data and local tests – anatomy of MapReduce job run – classic Map-reduce – YARN – failures in classic Map-reduce and YARN –job scheduling – shuffle and sort – task execution – MapReduce types – input formats – output formats.

UNIT IV BASICS OF HADOOP 9

Data format – analyzing data with Hadoop – scaling out – Hadoop streaming – Hadoop pipes – design of Hadoop distributed file system (HDFS) – HDFS concepts – Java interface – data flow- Hadoop I/O – data integrity – compression – serialization – Avro – file-based data structures -Cassandra – Hadoop integration.

UNIT V HADOOP RELATED TOOLS 9

Hbase – data model and implementations – Hbase clients – Hbase examples – praxis. Pig – Grunt– pig data model – Pig Latin – developing and testing Pig Latin scripts. Hive – data types and fileformats – HiveQL data definition – HiveQL data manipulation – HiveQL queries.

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / etc)

Software Requirements:

Cassandra, Hadoop, Java, Pig, Hive and HBase.

1. Downloading and installing Hadoop; Understanding different Hadoop modes. Startup scripts,Configuration files.
2. Hadoop Implementation of file management tasks, such as Adding files and directories, retrieving files and Deleting files
3. Implement of Matrix Multiplication with Hadoop Map Reduce
4. Run a basic Word Count Map Reduce program to understand Map Reduce Paradigm.
5. Installation of Hive along with practice examples.
6. Installation of HBase, Installing thrift along with Practice examples
7. Practice importing and exporting data from various databases.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1 Describe big data and use cases from selected business domains.
CO2 Explain NoSQL big data management.
CO3 Install, configure, and run Hadoop and HDFS.
CO4 Perform map-reduce analytics using Hadoop.
CO5 Use Hadoop-related tools such as HBase, Cassandra, Pig, and Hive for big data analytics.

TEXT BOOKS:

1. Michael Minelli, Michelle Chambers, and AmbigaDhiraj, "Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses", Wiley, 2013.
2. Eric Sammer, "Hadoop Operations", O'Reilley, 2012.
3. Sadalage, Pramod J. “NoSQL distilled”, 2013.

REFERENCES:

1. E. Capriolo, D. Wampler, and J. Rutherglen, "Programming Hive", O'Reilley, 2012.
2. Lars George, "HBase: The Definitive Guide", O'Reilley, 2011.
3. Eben Hewitt, "Cassandra: The Definitive Guide", O'Reilley, 2010.
4. Alan Gates, "Programming Pig", O'Reilley, 2011.

MAPPING COS AND POS:

COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	3	2	2	3	1	-	1	1	-	1	2	1	2	1	3
CO2	2	2	2	3	2	1	-	1	1	-	1	1	1	2	2	2
CO3	3	1	2	1	1	1	-	1	1	-	1	2	1	1	1	2
CO4	2	3	3	1	1	1	-	1	1	-	1	2	1	2	1	3
CO5	2	2	2	3	2	1	-	1	1	-	1	1	1	2	1	3
Avg	2.4	2.2	2.2	2	1.8	1	-	1	1	-	1	1.6	1	1.8	1.2	2.6

VERTICAL IV: ELECTRIC VEHICLE TECHNOLOGY

EE23025	ELECTRIC VEHICLE ARCHITECTURE AND DYNAMICS	L	T	P	C
		3	0	0	3

UNIT I EV HISTORY AND ITS EVOLUTION 9

Electric Vehicle History - IC Engines, BMEP and BSFC, Vehicle Fuel Economy, Emission Control Systems, Treatment of Diesel Exhaust Emissions, Evolution of Electric Vehicles (EVs) and Hybrid Electric Vehicles (HEVs).

UNIT I HEV ARCHITECTURE 9

Architecture of HEVs - Series, Parallel and Series Parallel Architecture, Micro and Mild architectures. HEVs in Hilly terrains - Electric Cars and Heavy Duty EVs - Details and Specifications.

UNIT III VEHICLE DYNAMICS 9

Vehicle dynamics - Roadway fundamentals, Laws of motion - Drive Cycles - Dynamics of vehicle motion, - velocity and acceleration, Tire-Road mechanics - Tractive Force/Power / Energy - Tractive System Design.

UNIT IV POWER COMPONENTS AND BRAKES 9

Power train Component sizing - Motors, Gears, Clutches, Differential, Transmission and Vehicle Brakes. EV power train sizing, HEV Powertrain sizing, Example.

UNIT V PLUG-IN HYBRID ELECTRIC VEHICLE 9

Introduction - History - Comparison with electric and hybrid electric Vehicle-Construction and working of PHEV-Block diagram and Components-Charging Mechanisms-Advantages of PHEVs.

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / etc)

Simulation of Electric Vehicle power components

- Simulation of drive cycles.
- Simulation of Power train components
- Simulation of Motors, Gears, Clutches
- Estimation of Torque/Power/Energy requirements for operation of EVs / HEVs

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

- **CO1** Summarize the History and Evolution of EVs, Hybrid and Plug-In Hybrid EVs and compare the same with the performance of internal combustion engine vehicles.
- **CO2** Describe the various EV components and its architecture
- **CO3** Describe the concepts related to the dynamics of EVs / HEVs and analyse its performance
- **CO4** Analyse the performance of EVs with power train mechanism
- **CO5** Describe the concept and performance of Plug-in hybrid electric vehicle

TEXT BOOKS:

1. Iqbal Hussain, “Electric and Hybrid Vehicles: Design Fundamentals, Second Edition” CRC Press, Taylor & Francis Group, Third Edition 2021.
2. Mehrdad Ehsani, YiminGao, Sebastian E. Gay, Ali Emadi, 'Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design', CRC Press, 2004.

REFERENCES:

1. Build Your Own Electric Vehicle,Seth Leitman , Bob Brant, McGraw Hill, Third Edition 2013.
2. Advanced Electric Drive Vehicles, Ali Emadi, CRC Press, First edition 2017.
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.
6. Hybrid Electric Vehicles: A Review of Existing Configurations and Thermodynamic Cycles, Rogelio León , Christian Montaleza , José Luis Maldonado , Marcos Tostado-Véliz and Francisco Jurado, Thermo, 2021.

Mapping COs and POs:

COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	-	2	-	-	-	-	1	-	-	-	2	3	-	-	1
CO2	3	-	2	-	-	-	-	1	-	-	-	2	3	3	3	3
CO3	3	-	2	-	-	-	-	1	-	-	-	2	3	-	-	3
CO4	3	-	2	-	-	-	-	1	-	-	-	2	3	-	-	3
CO5	3	-	3	3	3	-	-	1	-	-	-	2	3	3	3	3
Avg	3	-	2.2	3	3	-	-	1	-	-	-	2	3	3	3	2.6

EE23026		L	T	P	C
	ELECTRIC VEHICLE DESIGN, MODELLING AND CONTROL	**3**	**0**	**0**	**3**

UNIT I ESTIMATION OF VEHICLE PARAMETERS 9

Dynamics of Electric Vehicles - Tractive force - Maximum grade - distance, time and terminal velocity of vehicles- Maximum speed, torque, power, energy requirements of EVs for acceleration and standard drive cycles.

UNIT II CHOICE OF MOTORS FOR EVs / HEVs 9

Speed and Torque control below and above rated speed of motors - Speed control of EVs / HEVs. - DC Motors, Induction Motor, Permanent Magnet Synchronous Motors (PMSM), Brushless DC Motors, Switched Reluctance Motors (SRMs). Synchronous Reluctance Machines - Speed and torque range for EVs and HEVs - Choice of electric motors for EVs / HEVs.

UNIT III ESTIMATION OF BATTERY CAPACITY FOR EV APPLICATIONS 9

Batteries in Electric and Hybrid Vehicles - Battery Basics -Battery Parameters - Types: Lead Acid Battery - Nickel-Cadmium Battery - Nickel-Metal-Hydride (NiMH) Battery - Li-Ion Battery - Li-Polymer Battery, Zinc-Air Battery, Sodium-Sulphur Battery, Sodium-Metal-Chloride - Battery Models - Battery Pack Management - SoC / SoD / DoD of Battery - Estimation of battery capacity for EVs / HEVs for standard drive cycles.

UNIT IV ELECTRIC VEHICLE CONTROL STRATEGY 9

Vehicle supervisory control, Mode selection strategy, Modal Control strategies, Autonomous vehicles and its control.

UNIT V DESIGN AND MODELING OF EVs / HEVs 9

Design and Modeling of architecture and dynamics of EVs / HEVs for standard drive cycles for level roads and hilly terrains.

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / etc)

- Estimation of Torque / Power / Energy requirements of EVs / HEVs
- Modeling and Simulation of motors for EV/HEV applications
- Design, model and analyse the performance of Batteries.
- Simulation of vehicle architecture and dynamics and control of EVs / HEVs.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1 estimate and analyse the torque / power / energy requirements of EVs / HEVs
CO2 analyse the performance of motors for EV / HEV applications.
CO3 estimate the capacity of battery and anayse its performance for EV / HEV applications.
CO4 explain the concepts related with batteries and parameters of battery.
CO5 module the battery and to study the research and development for batteries.

TEXT BOOKS:

1. Electric and Hybrid Vehicles, Design Fundamentals, Third Edition, Iqbal Husain, CRC Press, 2021.
2. Wie Liu, “Hybrid Electric Vehicle System Modeling and Control”, Second Edition, John Wiley & Sons, 2017, 2nd Edition.

REFERENCES:

1. Ali Emadi, Mehrdad Ehsani, John M.Miller, “Vehicular Electric Power Systems”, Special Indian Edition, Marcel dekker, Inc 2003, 1st Edition.
2. C.C. Chan and K.T. Chau, 'Modern Electric Vehicle Technology', OXFORD University Press, 2001, 1st Edition.
3. Dynamic Simulation of Electric Machinery using MATLAB, Chee Mun Ong, Prentice Hall,1997, 1st Edition.
4. Electrical Machine Fundamentals with Numerical Simulation using MATLAB/ SIMULINK, Atif Iqbal, Shaikh Moinoddin, Bhimireddy Prathap Reddy, Wiley, 2021, 1st Edition.

Mapping COs and POs:

COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	-	-	-	-	-	-	-	1	2	-	2	3	-	3	-
CO2	3	3	3	3	3	-	-	-	1	3	-	2	3	-	3	3
CO3	3	-	1	3	3	-	3	-	1	2	-	2	3	-	3	3
CO4	3	-	-	-	3	-	3	-	1	2	-	2	3	-	3	3
CO5	3	-	3	-	-	-	3	-	1	2	-	2	3	2	3	3
Avg	3	3	2.3	3	3	-	3	-	1	2.2	-	2	3	2	3	3

EE23027

DESIGN OF ELECTRIC VEHICLE CHARGING SYSTEM	L	T	P	C
	3	0	0	3

UNIT I CHARGING STATIONS AND STANDARDS 9

Introduction-Charging technologies - On board/Off board chargers - Conductive charging, EV charging infrastructure, International standards and regulations - 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 POWER ELECTRONICS FOR EV CHARGING 9

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

UNIT III EV CHARGING USING RENEWABLE AND STORAGE SYSTEMS 9

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.

UNIT IV WIRELESS POWER TRANSFER 9

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 POWER FACTOR CORRECTION IN CHARGING SYSTEM 9

Need for power factor correction - Boost Converter for Power Factor Correction, Sizing the Boost Inductor, Average Currents in the Rectifier and calculation of power losses.

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / etc)

- Simulation and analysis for bi-directional charging V2G and G2V.
- Design and demonstrate solar PV based EV charging station.
- Simulate and infer wireless power charging station for EV charging.
- Simulation of boost converter based power factor correction.

TOTAL:45 PERIODS

COURSE OUTCOMES:

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

CO1 illustrate various charging techniques and to know charging standards and regulations.
CO2 demonstrate the working of DC-DC converters used for charging systems and principles.
CO3 demonstrate the principles of wireless power transfer.
CO4 analyze the standards for wireless charging.
CO5 design and simulate boost converter based power factor correction.

REFERENCES:

1. Mobile Electric Vehicles Online Charging and Discharging, Miao Wang Ran Zhang Xuemin (Sherman) Shen, Springer 2016, 1st Edition.
2. Alicia Triviño-Cabrera, José M. González-González, José A. Aguado, Wireless Power Transferor Electric Vehicles: Foundations and Design Approach, Springer Publisher 1st Edition. 2020.

3. Nil Patel, Akash Kumar Bhoi, Sanjeevikumar Padmanaban, Jens Bo Holm-Nielsen, Electric Vehicles Modern Technologies and Trends. Springer Publisher 1st Edition, 2021.
4. 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, 1st Edition.
5. Electric and Hybrid Electric Vehicles, James D Halderman, Pearson, 2022, 1st Edition.
6. Handbook of Automotive Power Electronics and Motor Drives, Ali Emadi, Taylor & Francis, 2005.

MAPPING COS AND POS:

COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	3	3	3	-	-	2	2	-	3	-	3	3	-	-	3
CO2	3	3	3	3	-	-	2	2	-	3	-	3	3	3	3	3
CO3	3	-	-	-	-	-	-	-	-	-	-	-	3	3	3	3
CO4	3	3	3	3	-	-	2	2	-	2	-	1	3	3	3	3
CO5	3	-	-	-	-	-	-	-	-	-	-	-	3	3	3	3
CO6	3	3	3	3	3	-	2	2	-	3	-	2	3	3	3	3
Avg	3	3	3	3	3	-	2	2	-	2.75	-	2.25	3	3	3	3

EE23028	TESTING OF ELECTRIC VEHICLES	L	T	P	C
		3	0	0	3

UNIT I EV STANDARDIZATION 9

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

UNIT II TESTING OF ELECTRIC MOTORS AND CONTROLLERS FOR ELECTRIC AND HYBRID ELECTRIC VEHICLES 9

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

UNIT III FUNDAMENTALS OF FUNCTIONAL SAFETY AND EMC 9

Functional safety life cycle - Fault tree analysis - Hazard and risk assessment – software development - Process models - Development assessments - Configuration management - Reliability - Reliability block diagrams and redundancy - Functional safety and EMC - Functional safety and quality - Standards - Functional safety of autonomous vehicles.

UNIT IV EMC IN ELECTRIC VEHICLES 9

Introduction - EMC Problems of EVs, EMC Problems of Motor Drive, EMC Problems of DC-DC Converter System, EMC Problems of Wireless Charging System, EMC Problem of Vehicle Controller, EMC Problems of Battery Management System, Vehicle EMC Requirements.

UNIT V EMI IN MOTOR DRIVE AND DC-DC CONVERTER SYSTEM 9

Overview - EMI Mechanism of Motor Drive System, Conducted Emission Test of Motor Drive System, IGBT EMI Source, EMI Coupling Path, EMI Modelling of Motor Drive System. EMI in DC-DC Converter, EMI Source, The Conducted Emission High-Frequency, Equivalent Circuit of DC-DC Converter System, EMI Coupling Path.

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / etc)

- Design and simulate motor controller for hybrid electric vehicle applications
- Simulation of EMC analysis for Wireless power transfer EV charging.
- Design and simulation of EMI filter

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1 describe the status and other details of standardization of EVs
CO2 illustrate the testing protocols for EVs and HEV components
CO3 analyze the safety cycle and need for functions safety for EVs
CO4 analyze the problems related with EMC for EV components
CO5 evaluate the EMI in motor drive and DC-DC converter system

REFERENCES:

- Handbook of Automotive Power Electronics and Motor Drives, Ali Emadi, Taylor & Francis, 2005, 1st Edition.
- Electromagnetic Compatibility of Electric Vehicle, Li Zhai, Springer 2021, 1st Edition.
- EMC and Functional Safety of Automotive Electronics, Kai Borgeest, IET 2018, 1st Edition.
- EMI/EMC Computational Modeling Handbook, Druce Archam beault, colin branch, Omar M.Ramachi ,Springer 2012, 2nd Edition.
- Automotive EMC, Mark Steffika, Springer 2013, 1st Edition.
- Electric Vehicle Systems Architecture and Standardization Needs, Reports of the PPP European Green Vehicles Initiative, Beate Müller, Gereon Meyer, Springer 2015, 1st Edition.

MAPPING COS AND POS:

COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	1	1	-	-	-	2	-	-	-	-	-	3	-	2	1
CO2	3	1	1	-	-	-	1	-	-	-	-	-	3	-	2	3
CO3	3	1	1	-	-	-	2	-	-	-	-	-	3	-	2	3
CO4	3	1	1	-	-	-	1	-	-	-	-	-	3	-	2	3
CO5	3	1	1	-	-	-	2	-	-	-	-	-	3	-	3	3
Avg	3	1	1	-	-	-	1.6	-	-	-	-	-	3	-	2.2	2.6

EE23029	GRID INTEGRATION OF ELECTRIC VEHICLES	L	T	P	C
		3	0	0	3

UNIT I DEFINITION, And STATUS Of V2G 9

Defining Vehicle to Grid (V2G) - History and Development of V2G. Incorporating V2G to the EV, Auditing and Metering, V2G in Practice, V2G - Power Markets and Applications. Electricity Markets and V2G Suitability, Long-Term Storage, Renewable Energy, and Other Grid Applications, Beyond the Grid.

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, Other Benefits.

UNIT III CHALLENGES TO V2G 9

Battery Degradation, Charger Efficiency, Aggregation and Communication, V2G in a Digital Society. Evaluating V2G Costs and Revenues , EV Costs and Benefits, V2G and Regulatory Frameworks , Market Design Challenges. Other V2G Regulatory and Legal Challenges.

UNIT IV IMPACT OF EV AND V2G ON THE SMART GRID AND RENEWABLE ENERGY SYSTEMS 9

Introduction - Types of Electric Vehicles - Motor Vehicle Ownership and EV Migration - Impact of Estimated EVs on Electrical Network - Standardization and Plug-and-Play - IEC 61850 Communication Standard and IEC 61850-7-420 Extension.

UNIT V GRID INTEGRATION AND MANAGEMENT OF EVS 9

Introduction - Machine to Machine (M2M) in distributed energy management systems - M2M communication for EVs - M2M communication architecture (3GPP) - Electric vehicle data logging - Scalability of electric vehicles -M2M communication with scheduling.

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/ Content Preparation / Quiz/ Surprise Test / etc)

- Simulation of connecting three phase inverter to the grid.
- Simulate and analyse the power quality issues of V2G systems
- Design and simulate battery management system for smart grid with distributed generation.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1 explain the concepts related with V2G
CO2 study the grid connection of 3 phase Q inverter
CO3 explain the technical, economics. business, regulatory & political challenges related with V2G
CO4 demonstrate the impact of EV and V2G on smart grid and renewable energy system
CO5 explain the concept of grid integration and management of EVs

REFERENCES:

1. Advanced Electric Drive Vehicles, Ali Emadi, CRC Press 2017, 1st Edition.
2. Plug In Electric Vehicles in Smart Grids, Charging Strategies, Sumedha Rajakaruna , Farhad Shahnia and Arindam Ghosh,Springer,2015, 1st Edition.
3. ICT for Electric Vehicle Integration with the Smart Grid, Nand Kishor [1;] Jesus Fraile-Ardanuy, IET 2020, 1st Edition.
4. Vehicle-to-Grid: Linking Electric Vehicles to the Smart Grid, Junwei Lu and Jahangir Hossain, IET 2015, 1st Edition.
5. Lance Noel · Gerardo Zarazua de Rubens Johannes Kester · Benjamin K. Sovacool, Vehicle-to-Grid A Sociotechnical Transition Beyond Electric Mobility, 2019, 1st Edition.

MAPPING COS AND POS:

COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	-	-	-	-	-	2	1	-	2	-	-	3	3	1	3
CO2	3	3	-	-	3	-	2	1	-	2	-	-	3	-	-	3
CO3	3	-	-	-	-	-	2	1	-	2	-	-	3	-	-	3
CO4	3	-	-	-	-	-	2	1	-	2	-	-	3	-	2	3
CO5	3	-	-	-	-	-	2	1	-	2	-	-	3	-	3	3
Avg	3	3	-	-	3	-	2	1	-	2	-	-	3	3	2	3

EE23030	ENERGY STORAGE SYSTEMS	L	T	P	C
		3	0	0	3

UNIT I INTRODUCTION 9

Necessity of energy storage – types of energy storage – comparison of energy storage technologies – Applications.

UNIT II THERMAL STORAGE SYSTEM 9

Thermal storage – Types – Modeling of thermal storage units – Simple water and rock bed storage system – pressurized water storage system – Modelling of phase change storage system – Simple units, packed bed storage units - Modelling using porous medium approach, Use of TRNSYS.

UNIT III ELECTRICAL ENERGY STORAGE 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 - Mathematical Modelling for Lead Acid Batteries – Flow Batteries.

UNIT IV HYDROGEN STORAGE SYSTEMS 9

Hydrogen production methods - hydrogen storage techniques - Electrolysers/Green hydrogen.

UNIT V ALTERNATE ENERGY STORAGE TECHNOLOGIES 9

Flywheel, Super capacitors, Principles of operation – Applications, Compressed air Energy storage, Concept of Hybrid Storage – Applications, Pumped Hydro Storage – Applications.

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / etc)

- Model, simulate and analyze the performance characteristics of thermal storage systems
- Develop a model for latent heat storage in phase changing materials.
- Model, simulate and analyze the performance characteristics of Batteries
- Model, simulate and analyze the performance characteristics of hydrogen fuel
- Techno-economic analysis of different types of storage systems

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1 Understand different types energy storage technologies
CO2 Design a thermal storage system
CO3 Unserstand and Model the battery storage system
CO4 Understad and analyse the hydrogen production and storage methods
CO5 Understand the alternate energy storage technologies.

TEXT BOOKS:

1. Ibrahim Dincer and Mark A. Rosen, ‘Thermal Energy Storage Systems and Applications’, John Wiley & Sons, 3rd Edition, 2021.
2. Ru-shi Liu, Lei Zhang and Xueliang sun, ‘Electrochemical technologies for energy storage and conversion’, Wiley publications, 2nd Volume set, 2012.
3. James Larminie and Andrew Dicks, ‘Fuel cell systems Explained’, Wiley publications, 3rd Edition, 2018.

REFERENCES:

1. Lunardini. V.J, 'Heat Transfer in Cold Climates', John Wiley and Sons 1981, 1st Edition.
2. Schmidt.F.W. and Willmott.A.J, 'Thermal Energy Storage and Regeneration', Hemisphere Publishing Corporation, 1981, 1st Edition.

List of Open Source Software/Learning website:

- Prof.Subhasish Basu Majumder, "Electrochemical Energy Storage", NPTEL Course, https://nptel.ac.in/courses/113105102.
- Prof. PK Das, "Energy conservation and waste heat recovery", NPTEL Course, https://nptel.ac.in/courses/112105221.

MAPPING COS AND POS:

	POs												PSOs			
COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**
CO1	3	1	-	-	-	-	-	-	-	-	-	-	2	-	3	3
CO2	3	-	2	-	-	-	-	-	-	-	-	-	2	-	3	3
CO3	3	-	2	-	-	-	-	-	-	-	-	-	2	-	3	3
CO4	3	-	2	-	-	-	-	-	-	-	-	-	2	-	3	3
CO5	3	-	2	-	-	-	-	-	-	-	-	-	2	-	3	3
CO6	-	3	-	-	-	2	-	1	-	-	-	-	2	-	3	3
Avg	3	2	2	-	-	2	-	1	-	-	-	-	2	-	3	3

VERTICAL V : MODERN CONTROL AND INDUSTRIAL AUTOMATION

EE23031	INDUSTRIAL AUTOMATION SYSTEMS	L	T	P	C
		3	0	0	3

UNIT I AUTOMATION COMPONENTS 9

Automation overview, Requirement of automation systems, Architecture of Industrial Automation system, Industrial bus systems: Modbus & Profibus. Sensors for temperature, pressure, force, displacement, speed, flow, level, humidity and pH measurement. Actuators, process control valves, power electronics devices DIAC, TRIAC, power MOSFET and IGBT. Introduction of DC and AC servo drives for motion control.

UNIT II COMPUTER AIDED MEASUREMENT AND CONTROL SYSTEMS 9

Role of computers in measurement and control, Elements of computer aided measurement and control, man-machine interface, computer aided process control hardware, process related interfaces, Communication and networking, Industrial communication systems, Data transfer techniques, Computer aided process control software, Computer based data acquisition system, Industrial Internet of things (IIoT) for plant automation, Introduction to Industry 4.0 framework.

UNIT III PROGRAMMABLE LOGIC CONTROLLERS 9

Programmable controllers, Programmable logic controllers, Analog digital input and output modules, PLC programming, Ladder diagram, Sequential flow chart, PLC Communication and networking, PLC selection, PLC Installation, Advantage of using PLC for Industrial automation, Application of PLC to process control industries.

UNIT IV DISTRIBUTED CONTROL SYSTEM 9

Overview of DCS, DCS software configuration, DCS communication, DCS Supervisory Computer Tasks, DCS integration with PLC and Computers, Features of DCS, Advantages of DCS.

UNIT V SCADA 9

Elements of SCADA system- History of SCADA, Remote Terminal Unit- Discrete control- Analog control, Master Terminal Unit- Operator interface.

TOTAL: 45 PERIODS

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc)

1. Develop criteria for selecting a robot for a specific industrial application.
2. Develop a project incorporating sensors to provide sensory feedback to a robot.
3. Create the control circuits for a manipulator.
4. Use simulation software to model a simple path planning application.
5. Analyze and present case studies of robots used in various industries.

COURSE OUTCOMES:

After completion the above subject, students will be able to

- **CO1** Explain the working of communication buses and sensors and drives used in automation industries.
- **CO2** Implement computer based data acquisition systems for various applications.
- **CO3** Explain architecture of PLC and develop ladder program for a given sequence of operation describe about computer aided measurements and various signal transmission techniques.
- **CO4** Integrate DCS with plcs and computers for comprehensive control
- **CO5** Utilize HMI software for real-time monitoring and control of industrial processes.

TEXT BOOKS

1. Terry L.M. Bartelt, "Industrial Automated Systems: Instrumentation and Motion Control" Cengage Learning, 2010.
2. Frank Lamb, "Industrial Automation: Hands On", McGraw-Hill Education, 2013.
3. John W. Webb and Ronald A. Reis, "Programmable Logic Controllers: Principles and Applications", 5th Edition, Prentice Hall Inc., New Jersey, 2003.

REFERENCES:

1. Frank D. Petruzella, "Programmable Logic Controllers", 5th Edition, McGraw- Hill, New York, 2016.
2. David Bailey & Edwin Wright,"Practical SCADA for Industry'', Elsevier 2010
3. Mehta B.R and Reddy Y.J, "Industrial Process Automation Systems: Design and Implementation", Waltham MA: Butterworth-Heinemann, 2015

Mapping COs and POs:																
COs	**POs**												**PSOs**			
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PO12**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**
CO1	3	3	3	-	3	2	-	2	-	-	-	3	3	3	3	3
CO2	3	3	3	2	-	2	-	-	-	3	-	3	3	3	3	3
CO3	3	3	3	-	3	2	-	-	-	-	-	3	3	3	3	3
CO4	3	3	3	-	-	-	-	2	-	3	-	3	3	3	3	3
CO5	3	3	3	2	3	-	-	-	-	3	-	3	3	3	3	3
Avg	3	3	3	2	3	2	-	2	-	3	-	3	3	3	3	3

EE23032	ROBOTICS AND AUTOMATION	L T P C 3 0 0 3

UNIT I INTRODUCTION TO ROBOTICS & AUTOMATION 9

Overview of Robotics & Automation – Principles and Strategies of Automation System –Hardware and software for Automation- Embedded Processors for Automation-Different Types of Robots – Various Generations of Robots - Asimov's Laws Of Robotics – Key components of a robot - Design Criteria for Selection of a Robot –Role of embedded system in Robotics and Automation - Recent trends.

UNIT II SENSORS AND DRIVE SYSTEMS 9

Hydraulic, Pneumatic And Electric Drive Systems – Understanding how motor power, current torque, friction co-efficient affect the design of a Robot - Determination of Motor HP and Gearing Ratio – Variable Speed Arrangements. Sensors – Classification based on sensing type (including Optical, Acoustic, Magnetic) -Proximity Sensors – Ranging Sensors – Speed & Displacement Sensing - Tactile Sensors – Vision Sensing -Smart Sensors - MEMS sensors.

UNIT III MANIPULATORS AND GRIPPERS 9

Introduction to Manipulators - Joints and Degrees of Freedom - Construction of Manipulators – Manipulator Dynamics And Force Control – Electronic And Pneumatic Manipulator Control Circuits – End Effectors – Various Types Of Grippers – Design Considerations.

UNIT IV KINEMATICS AND PATH PLANNING 9

Kinematic Equations – Forward and Inverse Kinematics - Solution Of Inverse Kinematics Problem – Jacobian based Velocity Kinematics– Various Path Planning Algorithms – Hill Climbing Techniques - Robot Operating System - Simulation and modeling of a simple Path Planning application.

UNIT V CASE STUDIES 9

Robot Cell Design - Humanoid Robot - Robots in healthcare applications – Robot Machine Interface – Robots in Manufacturing and Non-Manufacturing Applications - Self balancing robots - Micro/nano robots.

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc)

1. Develop criteria for selecting a robot for a specific industrial application.
2. Develop a project incorporating sensors to provide sensory feedback to a robot.
3. Create the control circuits for a manipulator.
4. Use simulation software to model a simple path planning application.
5. Analyze and present case studies of robots used in various industries.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

After completion the above subject, students will be able to

CO1 Choose suitable embedded boards for robots.
CO2 Implement sensing techniques for robotic applications.
CO3 Construct and understand the dynamics of manipulators and Grippers.
CO4 Use simulation tools to model robotic path planning applications.
CO5 Enhance problem-solving abilities and design innovative solutions for robotic and automation challenges.

TEXT BOOKS:

1. John J. Craig," Introduction to Robotics: Mechanics and Control" Pearson, 2017
2. Mark W. Spong, Seth Hutchinson, M. Vidyasagar, "Robot Modeling and Control" Wiley, 2020.

REFERENCES:

1. Mikell P. Weiss G.M., Nagel R.N., Odraj N.G., "Industrial Robotics", Mc Graw-Hill Singapore, 1996.
2. Ghosh, Control in Robotics and Automation: Sensor Based Integration, Allied Publishers, Chennai, 1998.
3. Fu K.S. Gonzaleaz R.C. And Lee C.S.G., "Robotics Control Sensing, Vision and Intelligence" McGraw Hill International Editions, 1987.
4. Robert J. Schilling, "Fundamentals of Robotics: Analysis and Control" Prentice Hall India Learning Private Limited, 1996

MAPPING COS AND POS:

	POs												PSOs			
COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PO12**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**
CO1	3	3	-	-	3	2	-	2	-	-	-	3	3	3	3	3
CO2	3	3	2	2	-	2	-	-	-	3	-	3	3	3	3	3
CO3	3	3	-	2	3	2	-	-	-	-	-	3	3	3	3	3
CO4	3	3	-	2	-	2	-	2	-	3	-	3	3	3	3	3
CO5	3	3	2	2	3	2	-	2	-	3	-	3	3	3	3	3
Avg	3	3	2	2	3	2	-	2	-	3	-	3	3	3	3	3

EE23033	MODEL BASED CONTROL	L	T	P	C
		3	0	0	3

UNIT I INTRODUCTION TO MIMO CONTROL 9

Introduction to MIMO Systems-Multivariable control-Multiloop Control-Multivariable IMC-IMCPID- Case studies.

UNIT II MODEL PREDICTIVE CONTROL SCHEMES 9

Introduction to Model Predictive Control - Model Predictive Control Elements - Generalized Predictive Control Scheme – Multivariable Generalized Predictive Control Scheme – Multiple Model based Model Predictive Control Scheme Case Studies.

UNIT III STATE SPACE BASED MODEL PREDICTIVE CONTROL SCHEME 9

State Space Model Based Predictive Control Scheme - Review of Kalman Update based filters – State Observer Based Model Predictive Control Schemes – Case Studies.

UNIT IV CONSTRAINED MODEL PREDICTIVE CONTROL SCHEME 9

Constraints Handling: Amplitude Constraints and Rate Constraints –Constraints and Optimization– Constrained Model Predictive Control Scheme – Case Studies.

UNIT V ADAPTIVE CONTROL SCHEME 9

Introduction to Adaptive Control-Gain Scheduling-Self tuning regulators–MARS-Adaptive Model Predictive Control Scheme –Case Studies.

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc)

1. Analyze case studies of MIMO control applications in various industries such as aerospace, automotive, and chemical processes..
2. Implement a MPC scheme and evaluate its performance through simulation.
5. Analyze a case study involving state-space-based predictive control schemes.
6. Develop a constrained MPC applications in energy management.
7. Implement an adaptive control scheme and evaluate its effectiveness in a simulated environment.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

After completion the above subject, students will be able to

CO1 Apply engineering knowledge to understand the control schemes on MIMO systems.
CO2 Design and analyze MPC schemes in various applications.
CO3 Develop state-space models for control systems and apply them in predictive control.
CO4 Analyze the impact of constraints on control system performance
CO5 Discuss the practical implications and advancements in adaptive control technology.

TEXT BOOKS:

1. Coleman Brosilow, Babu Joseph, “Techniques of Model-Based Control”, Prentice Hall PTR Pub 2002, 1st Edition.
2. E. F. Camacho, C. Bordons ,“Model Predictive Control”,Springer-Verlag London Limited 2007, 2nd Edition.
3. K.J. Astrom and B. J. Wittenmark, “Adaptive Control”, Second Edition, Pearson Education Inc., second Edition 2013.

REFERENCES:

1. Paul Serban Agachi, Zoltan K. Nagy, Mircea Vasile Cristea, and Arpad Imre-Lucaci Model Based Control Case Studies in Process Engineering, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim 2007.1st Edition.
2. Ridong Zhang, Anke Xue Furong Gao ,"Model Predictive Control Approaches Based on the Extended State Space Model and Extended Non-minimal State Space Model", Springer Nature Singapore Pte Ltd. 2019, 1st Edition.
3. J.A. ROSSITER "Model-Based Predictive Control A Practical Approach" Taylor & Francis e-Library, 2005, 1st edition.

MAPPING COS AND POS:

	POs												PSOs			
COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**
CO1	3	2	2	2	1	1	1	1	1	1	1	1	2	2	2	2
CO2	3	3	3	3	1	1	1	1	1	1	1	1	2	2	2	2
CO3	3	3	3	2	1	1	1	1	1	1	1	1	2	2	2	2
CO4	3	3	3	3	1	1	1	1	1	1	1	1	2	2	2	2
CO5	3	3	3	3	1	1	1	1	1	1	1	1	2	2	2	2
Avg	3	2.8	2.8	2.6	1	1	1	1	1	1	1	1	2	2	2	2

EE23034	NON LINEAR CONTROL	L T P C 3 0 0 3

UNIT I STATE VARIABLE DESIGN 9

Introduction to state Model- effect of state Feedback- Necessary and Sufficient Condition for Arbitrary Pole-placement- pole placement Design- design of state Observers- separation principle- servo design: - State Feedback with integral control.

UNIT II PHASE PLANE ANALYSIS 9

Features of linear and non-linear systems - Common physical non-linearities – Methods of linearization Concept of phase portraits – Singular points – Limit cycles – Construction of phase portraits – Phase plane analysis of linear and non-linear systems – Isocline method.

UNIT III DESCRIBING FUNCTION ANALYSIS 9

Basic concepts, derivation of describing functions for common non-linearities – Describing function analysis of non-linear systems – limit cycles – Stability of oscillations.

UNIT IV OPTIMAL CONTROL 9

Introduction - Time varying optimal control – LQR steady state optimal control – Solution of Ricatti's equation – Application examples.

UNIT V OPTIMAL ESTIMATION 9

Optimal estimation – Kalman Bucy Filter-Solution by duality principle -Discrete systems - Kalman Filter-Application examples.

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc)

1. Derive state-space models for a physical system.
2. Construct phase portraits for linear and non-linear systems using software tools.
3. Study the stability of oscillations and limit cycles using describing function analysis.
4. Solve Riccati equations and analyze their solutions for optimal control design.
5. Evaluate the performance of the Kalman filter in discrete-time applications.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

After completion the above subject, students will be able to

- **CO1** Understand and apply state-space models for control system representation
- **CO2** Analyze linear and non-linear systems using phase portraits and identify system behaviour.
- **CO3** Apply describing function analysis to predict stability and oscillatory behaviour in non-linear systems.
- **CO4** Design optimal control strategies using LQR and time-varying control techniques.
- **CO5** Implement Kalman filtering techniques for optimal state estimation in continuous and discrete systems.

TEXT BOOKS:

1. G. J. Thaler, "Automatic Control Systems", Jaico Publishing House 1993.
2. M.Gopal, Modern Control System Theory, New Age International Publishers,2002, 2ndEdition.
3. K. P. Mohandas, "Modern Control Engineering", Sanguine Technical Publishers, 2006, 1st Edition.

REFERENCES:

1. Ashish Tewari, 'Modern Control Design with Matlab and Simulink', John Wiley, New Delhi, 2002, 1st Edition.
2. K. Ogata, 'Modern Control Engineering', 5th Edition, PHI, New Delhi, 2009.
3. T. Glad and L. Ljung, "Control Theory –Multivariable and Non-Linear Methods", Taylor & Francis, 2002, 1st Edition.
4. D.S.Naidu, "Optimal Control Systems" First Indian Reprint, CRC Press, 2009, 1st Edition.
5. William S Levine, "Control System Fundamentals," The Control Handbook, CRC Press, Tayler and Francis Group, 2011, 2nd Edition.

MAPPING COS AND POS:

COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	2	2	2	1	1	1	3	1	3	1	1	2	2	2	2
CO2	3	3	3	2	1	1	1	3	1	3	1	1	2	2	2	2
CO3	3	2	2	2	1	1	1	3	1	3	1	1	2	2	2	2
CO4	3	3	3	3	1	1	1	3	1	3	1	1	2	2	2	2
CO5	2	1	2	1	1	1	1	2	1	2	1	1	2	2	2	2
Avg	2.8	2.2	2.4	2	1	1	1	2.8	1	2.8	1	1	2	2	2	2

EE23035	SYSTEM IDENTIFICATION	L	T	P	C
		3	0	0	3

UNIT I NON PARAMETRIC METHODS 9

Nonparametric methods: Transient analysis - frequency analysis - Correlation analysis - Spectral analysis.

UNIT II PARAMETRIC METHODS 9

The recursive least squares method - Recursive Instrumental variable method-the recursive prediction error method-model validation and model structure determination. Identification of systems operating in closed loop: Identifiability considerations - Direct identification - Indirect identification - Joint input – Output identification.

UNIT III RECURSIVE IDENTIFICATION METHODS 9

The recursive least squares method - Recursive Instrumental variable method-the recursive prediction error method-model validation and model structure determination. Identification of systems operating in closed loop: Identifiability considerations - Direct identification - Indirect identification - Joint input – Output identification.

UNIT IV CLOSED- LOOP IDENTIFICATION 9

Identification of systems operating in closed loop: direct identification and indirect identification– Subspace Identification methods: classical and innovation forms – Relay feedback identification of stable processes.

UNIT V NONLINEAR SYSTEM IDENTIFICATION 9

Modeling of nonlinear systems using ANN- NARX & NARMAX - Training Feed-forward and Recurrent Neural Networks – TSK model – Adaptive Neuro-Fuzzy Inference System (ANFIS) - Introduction to Support Vector Regression.

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc)

1. Implement transient, frequency, correlation, and spectral analyses on real or simulated data.
2. Utilize simulation software to create ARX, ARMAX, OE, and BJ models and compare their performance.
3. Apply least squares and instrumental variable methods in software environments to understand their application and limitations.
4. Analyze the mechanical/electrical using both parametric and nonparametric methods.
5. Develop a project that involves creating and validating a system model from experimental data.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

After completion the above subject, students will be able to

CO1 Understand and apply Nonparametric Methods
CO2 Apply parametric methods for estimation and understand their theoretical foundations.
CO3 Implement Recursive Identification Techniques in real time applications.
CO4 Implement identification techniques for systems operating in a closed loop.
CO5 Understand the identification methods for nonlinear systems.

TEXT BOOKS

1. Lennart Ljung, “System Identification: Theory for the user”, 2nd Edition, Prentice Hall, 1999.
2. Dan Simon, “Optimal State Estimation Kalman, H-infinity and Non-linear Approaches”, John Wiley and Sons, 2006,
3. Tangirala, A.K., “Principles of System Identification: Theory and Practice”, CRC Press, 2014, 1st Edition.

REFERENCES

1. Cortes, C., and Vapnik, V., “Support-Vector Networks, Machine Learning”, 1995, 1st Edition.
2. Miller, W.T., Sutton, R.S., and Webrose, P.J., “Neural Networks for Control”, MIT Press, 1996, 1st Edition.
3. Van der Heijden, F., Duin, R.P.W., De Ridder, D., and Tax, D.M.J., “Classification, Parameter Estimation and State Estimation”, An Engineering Approach Using MATLAB, John Wiley & Sons Ltd., 2017, 2nd Edition.
4. Karel J. Keesman, “System Identification an Introduction”, Springer, 2011, 1st Edition.
5. Tao Liu and Furong Gao, “Industrial Process Identification and control design, Step-test and relay-experiment-based methods”, Springer- Verlag London Ltd., 2012, 1st Edition

MAPPING COS AND POS:

COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	3	3	3	1	1	1	1	1	1	1	1	2	2	2	2
CO2	3	3	3	3	1	1	1	1	1	1	1	1	2	2	2	2
CO3	3	2	2	2	1	1	1	1	1	1	1	1	2	2	2	2
CO4	3	2	2	2	1	1	1	1	1	1	1	1	2	2	2	2
CO5	3	3	3	3	1	1	1	1	1	1	1	1	2	2	2	2
Avg	3	2.6	2.6	2.6	1	1	1	1	1	1	1	1	2	2	2	2

EE23036	ADAPTIVE CONTROL	L	T	P	C
		3	0	0	3

UNIT I INTRODUCTION 9

Introduction - Adaptive Schemes - The adaptive Control Problem – Applications-Parameter estimation:-LS, RLS: and ERLS.

UNIT II GAIN SCHEDULING 9

Introduction- The principle - Design of gain scheduling controllers- Nonlinear transformations - application of gain scheduling - Auto-tuning techniques: Methods based on Relay feedback.

UNIT III DETERMINISTIC SELF-TUNING REGULATORS 9

Introduction- Pole Placement design - Indirect Self-tuning regulators - direct self-tuning regulators – Disturbances with known characteristics.

UNIT IV STOCHASTIC AND PREDICTIVE SELF-TUNING REGULATORS 9

Introduction – Design of minimum variance controller - Design of moving average controller - stochastic self-tuning regulators.

UNIT V MODEL – REFERENCE ADAPTIVE SYSTEM 9

Introduction- MIT rule – Determination of adaptation gain - Lyapunov theory –Design of MRAS using Lyapunov theory – Relations between MRAS and STR.

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc)

1. Analysis/Problem Solving - Ability to identify and define problems and solutions
2. Develop and test both deterministic and stochastic self-tuning regulators.
3. Design a gain scheduling controller in simulation environment.
4. Evaluate the effectiveness of auto-tuning techniques based on relay feedback
5. Design MRAS using MIT rule and Lyapunov theory in simulation environments.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

After completion the above subject, students will be able to

CO1 Explain the fundamental concepts of adaptive control, including adaptive schemes, parameter estimation, and the adaptive control problem.

CO2 Design and Implement Gain Scheduling Controllers.

CO3 Implement deterministic self-tuning regulators and to analyse the unknown disturbances.

CO4 Design stochastic and predictive self-tuning regulators

CO5 Understand and design model-reference adaptive systems using the MIT rule and Lyapunov theory.

TEXT BOOKS:

1. K.J. Astrom and B. J. Wittenmark, “Adaptive Control”, Second Edition, Pearson Education Inc., second Edition 2013.
2. Landau, I. D., Lozano, R., M'Saad, M., & Karimi, A. "Adaptive Control: Algorithms, Analysis and Applications." Springer, 2011

REFERENCES:

1. T. Soderstorm and Petre Stoica, “System Identification”, Prentice Hall International(UK) Ltd., 1989, 1st Edition.
2. Lennart Ljung, “System Identification: Theory for the User”, Second Edition, Prentice Hall, 1999.
3. Ioannou, P. A., & Sun, J. "Robust Adaptive Control." Dover Publications, 2012.

MAPPING COS AND POS:

COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	2	2	2	1	1	1	3	1	1	1	1	2	2	2	2
CO2	3	2	2	2	1	1	1	3	1	1	1	1	2	2	2	2
CO3	3	3	3	3	1	1	1	3	1	3	1	1	2	2	2	2
CO4	3	3	3	3	1	1	1	3	1	3	1	1	2	2	2	2
CO5	3	2	2	2	1	1	1	3	1	1	1	1	2	2	2	2
CO6	3	2	2	2	1	1	1	3	1	1	1	1	2	2	2	2
Avg	3	2.3	2.3	2.3	1	1	1	3	1	1.6	1	1	2	2	2	2

EE23037 PROCESS MODELING AND SIMULATION L T P C
3 0 0 3

UNIT I GENERAL PRINCIPLES OF MODELLING

Introduction to mathematical modelling; Advantages and limitations of models and applications of process models of stand-alone unit operations and unit processes; Classification of models: Linear vs Nonlinear, lumped parameter vs. Distributed parameter; Static vs. Dynamic, Continuous vs. Discrete; Numerical Methods: Iterative convergence methods, Numerical integration of ODE- IVP and ODEBVP.

UNIT II MODELLING OF DISTRIBUTED PROCESSES 9

Steady state models giving rise to differential algebraic equation (DAE) systems; Rate based Approaches for staged processes; Modelling of differential contactors – distributed parameter models of packed beds; Packed bed reactors; Modelling of reactive separation processes; Review of solution strategies for Differential Algebraic Equations (DAEs), Partial Differential Equations (PDEs), and available numerical software libraries.

UNIT III INTRODUCTION TO PROCESS MODELLING 9

Concept of degree of freedom analysis: System and its subsystem, System interaction, Degree of freedom in a system e.g. Heat exchanger, Equilibrium still, Reversal of information flow, Design variable selection algorithm, Information flow through subsystems, Structural effects of design variable selection, Persistent Recycle.

UNIT IV MODELLING OF INDUSTRIAL PROCESSES 9

Simple examples of process models; Models giving rise to nonlinear algebraic equation (NAE) systems, -steady state models of flash vessels, equilibrium staged processes distillation columns, absorbers, strippers, CSTR, heat exchangers, etc.; Review of solution procedures and available numerical software libraries.

UNIT V SIMULATION OF MATHEMATICAL MODELLING 9

Simulation and their approaches, Modular, Sequential, Simultaneous and Equation solving approach, Simulation software and their applications, Review of solution techniques and available numerical software libraries. - Case Studies

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc)

1. Developing steady state /Dynamic mathematical model of different unit processes (ODE or PDE).
2. Simulation of steady state/ dynamic models using appropriate software.
3. Open loop study based on the developed mathematical model.
4. Apply different simulation approaches (modular, sequential, simultaneous) and evaluate their performance.
5. Development and simulation of unsteady state models for simple processes.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

After completion the above subject, students will be able to

CO1 Understand different methods of developing models for industrial processes.
CO2 Build mathematical models by applying relevant mathematics.
CO3 Implement mathematical models using relevant software.
CO4 Effectively perform analysis and subsequent conclusion for the developed mathematical models.
CO5 Interpret the results obtained from the mathematical model in terms of original real world problem.

TEXT BOOKS:

1. Denn M. M.,"Process Modeling", Longman, 1986, 1st Edition.
2. Bequette, B. W. "Process Dynamics: Modeling, Analysis and Simulation." Prentice Hall, 1998.
3. Marlin, T. E. "Process Control: Designing Processes and Control Systems for Dynamic Performance." McGraw-Hill, 2000.

REFERENCES:

1. Luyben W.L., “Process Modeling, Simulation, and Control for Chemical Engineering”, McGraw Hill, 2nd Edition, 1990.
2. D. F. Rudd and C. C. Watson, “Strategy of Process Engineering”, Wiley international, 1st Edition, 1968.
3. M.M. Denn, “Process Modelling”, Wiley, New York, 1st Edition, 1986.
4. K. Jana, “Chemical Process Modelling and Computer Simulation”, PHI,1st Edition, 2011.
5. C.D. Holland, “Fundamentals of Modelling Separation Processes”, Prentice Hall, , 1st Edition, 1975.
6. HussainAsghar, “Chemical Process Simulation”, Wiley Eastern Ltd., New Delhi, , 1st Edition, 1986.

MAPPING COS AND POS:

COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	1	-	-	2	1	-	1	1	1	1	1	1	2	2	2
CO2	3	1	2	-	-	1	-	1	1	1	1	1	1	2	2	2
CO3	1	-	2	3	-	1	-	1	1	1	1	1	1	2	2	2
CO4	1	-	3	-	-	1	2	1	1	1	1	1	1	2	2	2
CO5	1	2	-	3	-	1	-	1	1	1	1	1	1	2	2	2
Avg	1.8	1.33	2.3	3	2	1	2	1	1	1	1	1	1	2	2	2

EE23038	COMPUTER CONTROL OF PROCESSES	L	T	P	C
		3	0	0	3

UNIT I **DISCRETE STATE-VARIABLE TECHNIQUE** **9**

State equation of discrete data system with sample and hold – State transition equation – Methods of computing the state transition matrix – Decomposition of discrete data transfer functions – State diagrams of discrete data systems – System with zero-order hold – Controllability and observability of linear time invariant discrete data system–Stability tests of discrete-data system.

UNIT II **SYSTEM IDENTIFICATION** **9**

Identification of Non-Parametric Input-Output Models: -Transient analysis–Frequency analysis– Correlation analysis– Spectral analysis – Identification of Parametric Input-Output Models: - Least Squares Method – Recursive Least Square Method.

UNIT III **DIGITAL CONTROLLER DESIGN** **9**

Review of z-transform – Modified of z-transform – Pulse transfer function – Digital PID controller– Dead-beat controller and Dahlin's controller – Kalman's algorithm, Pole Placement Controller.

UNIT IV **MULTI-LOOP REGULATORY CONTROL** **9**

Multi-loop Control - Introduction – Process Interaction – Pairing of Inputs and Outputs -The Relative Gain Array (RGA) – Properties and Application of RGA - Multi-loop PID Controller – Biggest Log Modulus Tuning Method – De-coupler.

UNIT V **MULTIVARIABLE REGULATORY CONTROL** **9**

Introduction to Multivariable control –Multivariable PID Controller – Multivariable Dynamic Matrix Controller – Case Studies: - Distillation Column, CSTR and Four-tank system.

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc)

1. Calculate the RGA to determine the recommended pairing between controlled and manipulated variables for any system.
2. Seminar on LS, RLS methods.
3. Design of DMC for distillation Column, CSTR and Four-tank systemin MATLAB.
4. Design a Multi-loop & Multivariable controller for MIMO system.
5. Design a model for any industrial process using parametric & non-parametric system.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

After completion the above subject, students will be able to

CO1 Develop mathematical models for discrete time systems using state variable techniques and analyze the stability of the systems.

CO2 Construct models from input-output data by least square and recursive least square method.

CO3 Design different digital controllers to satisfy the required criterion.

CO4 Design a multi-loop controller and multivariable controller for multi-variable systems.

CO5 Design multivariable dynamic matrix controller for industrial processes.

TEXT BOOKS:

1. Stephanopoulos, G., “Chemical Process Control -An Introduction to Theory and Practice”, Prentice Hall of India, 1st Edition, 2015.
2. Sigurd Skogestad, Ian Postlethwaite, “Multivariable Feedback Control: Analysis and Design”, John Wiley and Sons, 2005, 2nd Edition.

REFERENCES:

1. Thomas E. Marlin, Process Control – Designing Processes and Control systems for Dynamic Performance, Mc-Graw-Hill,2000, 2nd Edition.
2. Gopal, M., “Digital Control and State Variable Methods”, Tata Mc Graw Hill, 4th Edition, 2017.
3. P. Albertos and A. Sala, “Multivariable Control Systems An Engineering Approach”, Springer Verlag, 1st Edition, 2004
4. Bequette, B.W., “Process Control Modeling, Design and Simulation”, Prentice Hall of India, 1st Edition, 2003.
5. Dale E. Seborg, Duncan A. Mellichamp, Thomas F. Edgar, “Process Dynamics and Control”, Wiley John and Sons, 4th Edition, 2016.

MAPPING COS AND POS:

COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	3	3	2	1	1	1	1	1	1	1	1	2	2	2	2
CO2	3	3	3	3	1	1	1	1	1	1	1	1	2	2	2	2
CO3	3	3	3	3	1	1	1	1	1	1	1	1	2	2	2	2
CO4	3	3	3	3	1	1	1	1	1	1	1	1	2	2	2	2
CO5	3	3	3	3	1	1	1	1	1	1	1	1	2	2	2	2
Avg	3	3	3	2.8	1	1	1	1	1	1	1	1	2	2	2	2

OPEN ELECTIVE COURSES

EE23901	INTRODUCTION TO CONTROL SYSTEMS	L	T	P	C
		3	0	0	3

UNIT I MATHEMATICAL MODELS OF PHYSICALSYSTEMS 9

Definition & classification of system – terminology & structure of feedback control theory – Analogous systems - Physical system representation by Differential equations – Block diagram reduction– Signal flow graphs.

UNIT II TIME RESPONSE ANALYSIS & ROOTLOCUSTECHNIQUE 9

Standard test signals – Steady state error & error constants – Time Response of I and II order system– Root locus–Rules for sketching rootloci.

UNIT III FREQUENCY RESPONSE ANALYSIS 9

Correlation between Time & Frequency response – Polar plots – Bode Plots – Determination of Transfer Function from Bode plot.

UNIT IV STABILITY CONCEPTS & ANALYSIS 9

Concept of stability – Necessary condition – RH criterion – Relative stability – Nyquist stability criterion – Stability from Bode plot – Relative stability from Nyquist & Bode – Closed loop frequency response.

UNIT V STATE VARIABLE ANALYSIS 9

Concept of state – State Variable & State Model – State models for linear & continuous time systems– Solution of state & output equation–controllability & observability.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, the students will be able to

- **CO1** design the basic mathematical model of physical System.
- **CO2** analyze the time response analysis and techniques.
- **CO3** analyze the transfer function from different plots.
- **CO4** apply the stability concept in various criterion.
- **CO5** assess the state models for linear and continuous Systems.

TEXT BOOKS:

1. Farid Golnarghi , Benjamin C. Kuo, Automatic Control Systems Paper back, McGraw Hill Education, 2018.
2. Katsuhiko Ogata, 'Modern Control Engineering', Pearson, 5th Edition2015.
3. J. Nagrath and M. Gopal, Control Systems Engineering (Multi Colour Edition), New Age International, 2018.

REFERENCES:

1. Richard C. Dorf and Robert H. Bishop, Modern Control Systems, Pearson Education, 2010.
2. Control System Dynamics" by Robert Clark, Cambridge University Press, 1996 USA.
3. John J. D'Azzo, Constantine H. Houpis and Stuart N. Sheldon, Linear Control System AnalysisandDesign, 5th Edition, CRC PRESS, 2003.
4. S. Palani, Control System Engineering, McGraw-Hill Education Private Limited, 2009.

5. Yaduvir Singh and S.Janardhanan, Modern Control, Cengage Learning, First Impression 2010.

Mapping COs and POs:																
COs	**POs**												**PSOs**			
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**
CO1	3	3	3	2	2											
CO2	3	3	2	3	1											
CO3	3	3	3	2	2											
CO4	3	3	3	2	2											
CO5	3	3	3	1	1											
Avg	3	3	2.8	2	1.6											

EE23902	ELECTRIC VEHICLE TECHNOLOGIES	L	T	P	C
		3	0	0	3

UNIT I ROTATING POWER CONVERTERS 9

Magnetic circuits- DC machine and AC machine –Working principle of Generator and Motor-DC and AC - Voltage and torque equations – Characteristics and applications. Working principle of special machines like: Brushless DC motor, Switched reluctance motor and PMSM.

UNIT II STATIC POWER CONVERTERS 9

Working and Characteristics of Power Diodes, MOSFET and IGBT. Working of uncontrolled rectifiers, controlled rectifiers (Single phase and Three phase), DC choppers, single and three phase inverters, Multilevel inverters and Matrix Converters.

UNIT III CONTROL OF DC AND AC MOTOR DRIVES 9

Speed control for constant torque, constant HP operation of all electric motors - DC/DC chopper based four quadrant operation of DC motor drives, inverter based V/f Operation (motoring and braking) of induction motor drives, Transformation theory, vector control operation of Induction motor and PMSM, Brushless DC motor drives, Switched reluctance motor (SRM) drives.

UNIT IV HYBRID ELECTRIC VEHICLE ARCHITECTURE AND POWER TRAIN COMPONENTS 9

History of evolution of Electric Vehicles - Comparison of Electric Vehicles with Internal Combustion Engines - Architecture of Electric Vehicles (EV) and Hybrid Electric Vehicles (HEV) – Plug-in Hybrid Electric Vehicles (PHEV)- Power train components and sizing, Gears, Clutches, Transmission and Brakes.

UNIT V MECHANICS OF HYBRID ELECTRIC VEHICLES AND CONTROL OF VEHICLES 9

Fundamentals of vehicle mechanics - tractive force, power and energy requirements for standard drive cycles of HEV's - motor torque and power rating and battery capacity. HEV supervisory control - Selection of modes - power spilt mode - parallel mode - engine brake mode - regeneration mode - series parallel mode.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, the students will be able to

- **CO1** understand the principles of conventional and special electrical machines
- **CO2** acquire the concepts of power devices and power converters
- **CO3** understand the control for DC and AC drive systems
- **CO4** learned the electric vehicle architecture and power train components
- **CO5** acquire the knowledge of mechanics of electric vehicles and control of electric vehicles

REFERENCES:

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. Paul C. Krause, Oleg Wasynczuk, Scott D. Sudhoff, Steven D. Pekarek “Analysis of Electric Machinery and Drive Systems”, 3rd Edition, Wiley-IEEE Press, 2013.
4. Rashid M.H., “Power Electronics Circuits, Devices and Applications ", Pearson, fourth Edition, 10th Impression 2021.

5 Iqbal Husain, ‘Electric and Hybrid Electric Vehicles’, CRC Press, 2021.
6 Wei Liu, ‘Hybrid Electric Vehicle System Modeling and Control’, Second Edition, WILEY, 2017
7 James Larminie and John Lowry, ‘Electric Vehicle Technology Explained’, Second Edition, Wiley, 2012

Mapping COs and POs:																
COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	2	-	-	3	-	-	-	-	-	-	-	-	-	-	-
CO2	3	2	2	-	-	3	-	-	3	-	-	-	-	-	-	-
CO3	3	-	-	3	-	2	2	-	-	-	-	-	-	-	-	-
CO4	3	2	2	-	3	-	-	-	-	-	-	-	-	-	-	-
CO5	3		2	-	-	-	-	-	-	-	2	-	-	-	-	-
Avg	3	2	2	3	3	2.5	2	-	3	-	2	-	-	-	-	-

EE23903	INTRODUCTION TO EMBEDDED SYSTEMS	L	T	P	C
		3	0	0	3

UNIT I BASICS OF EMBEDDED SYSTEMS 9

Definition and characteristics of embedded systems, Embedded systems design process- Processor architectures -Memory organization and Types-Peripherals-RTOS-IDE.

UNIT II COMMUNICATION IN EMBEDDED PROCESSOR 9

Serial and parallel communication protocols-UART- Inter Integrated Circuits (I2C)–Wireless protocol based on Wifi, Bluetooth.

UNIT III EMBEDDED SYSTEM APPLICATIONS 9

IoT and embedded systems- Smart Meter –washing machine –mobile phone- building robots with embedded systems-home automation.

UNIT IV EMBEDDED PROCESSOR 9

Architecture of Arduino- ADC-sensor and LED interfacing- Programming with Arduino-IDE.

UNIT V CASE STUDIES 9

Arduino-based Real Time Digital Clock - Room Temperature Monitoring- Motor Control- Traffic Light Control.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

After completion the above subject, students will be able to

- **CO1** understand the basics of embedded systems
- **CO2** be able to select proper communication for a specific application
- **CO3** be able to know the various applications of embedded systems
- **CO4** understand the architecture of processor and programming methods
- **CO5** be able to develop embedded systems solutions for different real time applications

REFERENCES:

1. Rajkamal, ‘Embedded system-Architecture, Programming, Design’, TMH,2011.
2. Peckol, “Embedded system Design”,JohnWiley&Sons,2010
3. Lyla B Das,” Embedded Systems-An Integrated Approach”, Pearson,2013
4. EliciaWhite,”Making Embedded Systems”,O’Reilly Series,SPD,2011
5. Shibu.K.V, “Introduction to Embedded Systems”, Tata Mcgraw Hill,2009
6. Tammy Noergaard, ”Embedded System Architecture, A comprehensive Guid for Engineers and Programmers”, Elsevier, 2006.

Mapping COs and POs:

COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	3	2	2	3	2	1	1	1	-	2	2	-	-	-	-
CO2	2	2	3	2	3	2	1	1	2	-	2	2	-	-	-	-
CO3	2	3	1	2	1	1	1	1	1	-	2	1	-	-	-	-
CO4	3	3	1	1	2	1	1	1	1	-	2	1	-	-	-	-
CO5	2	1	2	3	3	1	1	1	1	-	2	1	-	-	-	-
Avg	2.4	2.4	1.8	2	2.4	1.4	1	1	1.2	-	2	1.4	-	-	-	-

SKILL DEVELOPMENT COURSES

EE23S01	PROGRAMMABLE LOGIC CONTROLLER LABORATORY	L	T	P	C
		0	0	2	1

LIST OF EXPERIMENTS

1. Basics of PLC-Programmable Logic Controllers- Parts of a PLC-Principles of Operation-PLCs versus Computers-PLC Size and Application-I/O Section- Discrete I/O Modules- Analog I/O Modules- Central Processing Unit – PLC programming languages.
2. Introduction to Ladder Diagram and implementation of Logic gates using Ladder Logic Programs
3. Timer Instructions On-Delay Timer Instruction –Off- Delay Timer Instruction and implementation of Timers
4. Up-Counter and Down-Counter Instructions and implementation
5. Implementation of forward and reverse direction control of Motors
6. Implementation of speed control of induction motor
7. Position control of servo motor
8. Implementation of ladder logic program to turn ON and turn OFF DC motor
9. Development of PLC program to sort the defective parts in conveyor
10. Control of the robot arm movement using PLC

TOTAL: 30 PERIODS

COURSE OUTCOMES:

After completion of the above subject, students will be able to

- **CO1** Understand the basics of PLC programming
- **CO2** Understand and implement the instructions of PLC
- **CO3** Implement the counters and timers using PLC program
- **CO4** Develop the PLC program for various applications
- **CO5** Design and analyze the industrial process using PLC

TEXT BOOKS:

1. Frank D. Petruzella, “Programmable Logic Controllers”, 5th Edition, McGraw- Hill, New York, 2019.

REFERENCES:

1. Bolton. W, “Programmble Logic Controllers”, Elsevier Newnes, 6th Edition 2015

Mapping COs and POs:

COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	3	2	2	3	1	-	-	1	-	1	2	3	3	2	1
CO2	2	2	3	2	2	1	-	-	1	-	1	2	2	3	2	2
CO3	2	3	1	2	1	1	-	-	1	-	1	1	1	1	1	2
CO4	3	2	1	1	2	1	-	-	1	-	1	1	1	2	1	1
CO5	2	1	2	3	3	1	-	-	1	-	1	1	2	2	1	3
Avg	2.4	2.2	1.8	2	2.2	1	-	-	1	-	1	1.3	1.8	2.2	1.4	1.8

EE23S02	SIMULATION TOOLS FOR POWER SYSTEM STUDIES	L	T	P	C
		0	0	2	1

LIST OF EXPERIMENTS

1. System Studies
   (i) Power Flow Analysis
   (ii) Short Circuit Analysis
   (iii) Stability Analysis
2. Motor Starting Analysis.
3. Power Factor Correction Studies.
4. Relay Coordination study.
5. Voltage and Frequency regulation of autonomous microgrid.
6. Virtual Synchronous Generator for autonomous microgrid.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

After completion of the above subject, students will be able to

CO1	Analyze and perform system studies using simulation tools
CO2	Analyze and perform motor starting analysis using simulation tools
CO3	Analyze and perform power factor correction studies using simulation tools
CO4	Analyze and perform relay coordination studies using simulation tools
CO5	Understand and perform Voltage and Frequency regulation in autonomous microgrid.

REFERENCES:

1. John J. Grainger, William D. Stevenson, Jr, ‘Power System Analysis’, Mc Graw Hill Education (India) Private Limited, New Delhi, 2015.
2. Kothari D.P. and Nagrath I.J., ‘Power System Engineering’, Tata McGraw-Hill Education, Second Edition, 2008.
3. Hadi Saadat, ‘Power System Analysis’, Tata McGraw Hill Education Pvt. Ltd., New Delhi, 21st reprint, 2010.
4. Allen. J. Wood and Bruce F. Wollen Berg, ‘Power Generation, Operation and Control’, John Wiley & Sons, Inc., 2016.
5. Nikos Hatziargyriou, Microgrids: Architectures and Control, John Wiley and Sons Ltd, 2014.

Mapping COs and POs:

COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	2	2	1	-	3	1	1			1	1	1	2	-	1	-
CO2	2	2	1	-	3	1	1			1	1	1	2	-	1	-
CO3	2	2	1	-	3	1	1			1	1	1	2	-	1	-
CO4	2	2	1	-	3	1	1			1	1	1	2	-	1	-
CO5	2	2	1	-	3	1	1			1	1	1	2	-	1	-
Avg	2	2	1	-	3	1	1			1	1	1	2	-	1	-

EE23S03	ELECTRIC VEHICLES POWERTRAIN SIMULATION	L	T	P	C
		0	0	2	1

LIST OF EXPERIMENTS

1) Electric Motor Modeling:
   - ❖ Investigation of PMSM/BLDC/SRM characteristics using simulation software.
   - ❖ Analysing the speed-torque characteristics under various loads and standard drive cycles.
2) Battery Modeling and Simulation:
   - ❖ Modelling of a typical EV battery and simulate Charge/discharge using equivalent circuit models.
   - ❖ Design of battery for a specific EV application and analyze its performance
3) Powertrain Efficiency Simulation:
   - ❖ Design of powertrain components for a specific EV application.
   - ❖ Simulation study of integrated motor, battery, and converter models of the entire EV powertrain.
   - ❖ Analysing the overall efficiency under different driving scenarios.

TOTAL: 30 PERIODS

COURSE OUTCOMES:

After completion of the above subject, students will be able to

CO1	Design and Simulate Control for EV Powertrain Motors (PMSM/BLDC/SRM)
CO2	Analyze and Apply Communication Protocols for EV Subsystems
CO3	Integrate Battery Pack Discharge Simulation with Equivalent Circuit Models
CO4	Simulate Overall EV Powertrain Efficiency under Different Driving Scenarios
CO5	Design and simulate power train components for Specific EV Applications

REFERENCE BOOKS & MATERIALS:

1. Electric and Hybrid Vehicles: Design Fundamentals by Iqbal Husain (3rd edition, 2018)
2. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design by Mehrdad Ehsani, Yimin Gao, and Ali Emadi (3rd edition, 2018)
3. Electric and Hybrid Vehicles: Modeling, Simulations and Control by Amir Khajepour and Liang Qu (2nd edition, 2014)
4. Simulation of Electric Machinery and Drives by Simulink (MathWorks) (https://www.mathworks.com/videos/motor-control-design-with-matlab-and-simulink-1563169611494.html)
5. Battery Management Systems for Electric Vehicles by Gregory L. Plett (2nd edition, 2015)
6. Power Electronics Handbook by Muhammad H. Rashid (4th edition, 2017)
7. Advanced Electric Drives for Vehicular Applications by Lars E. Gooden (2nd edition, 2016)

LIST OF OPEN SOURCE SOFTWARE/ LEARNING WEBSITES

1. Open FOAM: https://openfoam.org/
2. Simscape (MathWorks): https://www.mathworks.com/products/simscape.html
3. Open VehicleSim: https://www.openbible.org/about/regions/east-region/east-region-
4. PyBaLi: https://github.com/ali-bouali

5. Pandas & Matplotlib: https://pandas.pydata.org/, https://matplotlib.org/
6. NPTEL: Electric Vehicle Technology: https://nptel.ac.in/courses/108106170
7. IEEE Transportation Electrification Community: https://tec.ieee.org/

Mapping COs and POs:																
COs	**POs**												**PSOs**			
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**
CO1	3	2	2	2	1								2	3	3	3
CO2	3	2	3	2	1								2	3	3	3
CO3	3	3	2	3	1								2	3	3	3
CO4	3	2	2	2	1								2	3	3	3
CO5	3	2	1	2	1				1				2	3	3	3
Avg	3	2.2	2	2.2	1				1				2	3	3	3

EE23S04	PROCESSORS FOR MOTOR CONTROL APPLICATION	L	T	P	C
		0	0	2	1

LIST OF EXPERIMENTS

1. Duty cycle control for DC-Dc converters.
2. PWM generator for inverter applications
3. Speed Sensing
4. Current Sensing
5. Display Interface
6. Waveform Generation using DAC interface
7. Stepper Motor Control
8. DC motor Speed Control

TOTAL: 15 PERIODS

COURSE OUTCOMES:

After completion of the above subject, students will be able to

CO1 Generate required gating signal for DC-DC converters
CO2 Generate PWM signals for various modulation indices
CO3 Measure and display the parameters like speed and current
CO4 Control the stepper motor in the open loop mode
CO5 Perform Speed Control of DC motor

Mapping COs and POs:																
COs	POs												PSOs			
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	2	2	3	1	3	-	-	-	3	2	1	2	2	2	2	2
CO2	2	2	3	1	3	-	-	-	3	2	1	2	2	2	2	2
CO3	2	2	3	1	3	-	-	-	3	2	1	2	2	2	2	2
CO4	2	2	3	1	3	-	-	-	3	2	1	2	2	2	2	2
CO5	2	2	3	1	3	-	-	-	3	2	1	2	2	2	2	2
Avg	2	2	3	1	3	-	-	-	3	2	1	2	2	2	2	2

MINOR ELECTIVES

EE23039 POWER ELECTRONICS FOR ELECTRIC VEHICLES L T P C
3 0 0 3

UNIT I POWER SEMICONDUCTOR DEVICES AND CHARACTERISTICS 9

Operating principle and switching Characteristics: Power diodes - Power BJT, Power MOSFET, IGBT, SCR, GTO, Power integrated circuits (PIC) – Drive and Protection circuits – SiC and GaN devices.

UNIT II CONTROLLED RECTIFIERS 9

Single phase – Three phase – Half controlled – Fully controlled rectifiers – Dual converters -Effect of source and load inductance, Performance parameters calculation.

UNIT III DC TO DC CONVERTERS 9

Step up and Step-down Chopper – Chopper classification - quadrant of operation – Switching mode Regulators – Buck, Boost, and Buck-Boost Regulators- Design of DC –DC Converters. Introduction to Dual Active Bridge Converters.

UNIT IV INVERTERS 9

Voltage source Inverters –1-PhaseHalf bridge and Full bridge –3-Phase Bridge Inverters – Voltage control –PWM Techniques – Current Source Inverters Multilevel Inverters- Types-Principle of Operation.

UNIT V 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 and Zero Voltage Switching of Quasi Resonant Buck converter- Zero Current and Zero Voltage Switching of Quasi Resonant Boost converter: Steady State analysis.

TOTAL : 45 PERIODS

COURSE OUTCOMES (COs)

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

CO 1 Explain and analyse operations, characteristics and protection of power semiconductor devices.
CO 2 Classify, analyze and design, Controlled rectifier .
CO 3 Classify, analyze and design of DC to DC converters.
CO 4 Understand the principle of soft switching and resonant converters.
CO 5 Design and analyze inverters.

TEXT BOOKS:

1. Rashid, M.H., “Power Electronics – Circuits, Devices and Applications”, PHI, Fourth edition, 2014.
2. Mohan, Undeland and Robbins., “Power Electronics”, John Wiley and Sons, New York, 3rd edition 2006.
3. Bimbhra, P.S., “Power Electronics”, Khanna Publishers, 5th edition, 2012.

REFERENCES:

1. John G. Kassakian, Martin F. Schlecht, George C. Verghese, “Principles of Power Electronics”, Pearson, India, New Delhi, 2010.
2. Philip T Krein, “Elements of Power Electronics”, Oxford University Press, 1998.
3. Ned Mohan, “Power Electronics: A first course”, John Wiley, 2011.
4. Issa Batarseh, Ahmad Harb, “Power Electronics- Circuit Analysis and Design, Second edition, 2018.
5. Dehong Xu, Rui Li, Ning He, Jinyi Deng, Yuying Wu, Soft-Switching Technology for Three-phase Power Electronics Converters, IEEE Press, 2022.
6. Fang Lin Luo, Hong Ye, Power Electronics Advanced Conversion Technologies, Second edition, CRC Press, 2018.
7. Deshang Sha, Guo Xu, High-Frequency Isolated Bidirectional Dual Active Bridge DC–DC Converters with Wide Voltage Gain, Springer 2019.

EE23040 **APPLIED THERMODYNAMICS** **L T P C**
3 0 0 3

UNIT I BASICS, ZEROTH AND FIRST LAW 9

Basics Concepts – Thermodynamic systems, Properties and processes Thermodynamic Equilibrium - Displacement work - P-V diagram. Thermal equilibrium - Zeroth law. First law – application to closed and open systems – steady and unsteady flow processes. Properties of Ideal gas- Ideal and real gas comparison.

UNIT II SECOND LAW AND ENTROPY 9

Heat Reservoir, source and sink. Heat Engine, Refrigerator, Heat pump. Statements of second law and its corollaries. Carnot cycle, Reversed Carnot cycle, Performance. Clausius inequality. Concept of entropy, Principle of increase in entropy.

UNIT III GAS AND STEAM POWER CYCLES 9

Air Standard Cycles - Otto, Diesel, Dual, Brayton Cycle, Basic layout of Open and closed cycle Gas turbine, Ideal Rankine cycle (Descriptive type).

UNIT IV INTERNAL COMBUSTION ENGINES AND COMBUSTION 9

IC engine – Classification, working, components and their functions, two stroke & four stroke, and SI & CI engines – working & comparison. Combustion in SI & CI Engines – Performance parameters and calculations.

UNIT V INTERNAL COMBUSTION ENGINE SYSTEMS 9

Carburetor, Spark Plug, Fuel Injection System, Multipoint Fuel Injection system and Common Rail Direct Injection systems. Ignition systems – Magneto, Battery and Electronic. Lubrication and Cooling systems. Concepts of Supercharging and Turbocharging – Emission Norms.

TOTAL = 45 PERIODS

TEXT BOOKS:

1. Nag.P.K., Basic and Applied Thermodynamics, 2ndh Edition, Tata McGraw Hill (2010), New Delhi
2. Mahesh Rathore ,Thermal Engineering, Tata Mc Graw Hill (2010), New Delhi

REFERENCES:

1. Cengel, Y and M. Boles, Thermodynamics - An Engineering Approach, Tata McGraw Hill,8th Edition, 2015.
2. Ganesan V, Internal Combustion Engines, Third Edition, Tata Mcgraw-Hill. (2012).
3. Rajput. R. K., Thermal Engineering, S.Chand Publishers (2017).
4. Kothandaraman.C.P., Domkundwar. S,Domkundwar. A.V., A course in thermal Engineering", Fifth Edition, Dhanpat Rai & sons (2016).
5. R.P. Mathur, M.L.Sharma, Internal Combustion Engines, Dhanpat Rai Publication (2005)

CO-PO MAPPING

COs	POs												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	2	1	-	-	-	-	1	-	-	-		-	1	-	-
2	2	1	1	-	-	-	1	-	1	-	1	-	1	-	1
3	2	1	1	-	-	-	1	-	1	-	1	-	1	-	1
4	2	1	1	-	-	-	1	-	1	-	1	-	1	-	1
5	2	1	1	-	-	-	1	-	1	-	1	-	1	-	1
Avg.	2	1	1	-	-	-	1	-	1	-	1	-	1	-	1

EE23041 ELECTRICAL MACHINES AND DRIVES

L	T	P	C
3	0	0	3

UNIT I DC MACHINES AND TRANSFORMERS 9

DC Generator: Principle of operation -EMF equation - Characteristics DC- Motor working principle- Torque Equation-Characteristics - Starters - Speed Control-Applications of DC machines.

Transformer - Principle - Theory of ideal transformer - EMF equation - Construction -- Equivalent circuit –Performance

UNIT II AC MACHINES 9

Three phase Induction motor: -Types and principle of operation - toque-slip characteristics-Starting and speed control

Alternators: Principle of operation, Voltage regulation - Synchronous motor: Principle of operation-Starting.

UNIT III SPECIAL MACHINES 9

Doubly fed Induction Machine-Permanent magnet synchronous motor, Brushless DC motor, Switched reluctance motor Working principle-Governing equations and Control.

UNIT IV DC DRIVES 9

Modeling of drive elements – Equivalent circuit, transfer function of self, separately excited DC motors; Linear Transfer function model of power converters; Sensing and feeds back elements - Closed loop speed control – current and speed loops, P, PI and PID controllers

UNIT V AC DRIVES 9

Scalar Control of Induction motor, Characteristics. Reference frame theory: transformation of variables from stationary to arbitrary reference frame - variables observed from several frames of reference, Vector Control and Direct Torque control.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Fitzgerald A.E., Kingsley C., Umans, S. and Umans S.D., “Electric Machinery”, 6th Edition, McGraw-Hill, 2003.
2. Kothari, D.P., I.J. Nagrath, I.J.,“Electric Machines”, 5th edition, McGraw Hill Education,2017.

REFERENCE BOOKS:

1. Paul C.Krause, Oleg Wasyzczuk, Scott S, Sudhoff, “Analysis of Electric Machinery and Drive Systems”, John Wiley, Second Edition, 2010.
2. Stephen Chapman, “Electric Machinery Fundamentals”, 4th edition, McGraw Hill Education. 2017.
3. Gopal K Dubey, “Power Semiconductor controlled Drives”, Prentice Hall Inc., NewYersy, 1989.
4. R.Krishnan, “Electric Motor Drives – Modeling, Analysis and Control”,Prentice-Hall of India Pvt. Ltd., New Delhi,2010.
5. Ashfaq Husain and Harroon Ashfaq., “Electric Machines”, 3rd edition, Dhanpat Rai & Co., 2016.

EE23042	CONTROL SYSTEM DESIGN FOR ELECTRIC VEHICLE APPLICATIONS	L T P C 3 0 0 3

UNIT I MODELING OF LINEAR TIME INVARIANT SYSTEM (LTIV) 9

Control system: Open loop and Closed loop – Feedback control system characteristics – First principle modeling: Mechanical, Electrical and Electromechanical systems – Transfer function representations: Block diagram

UNIT II TIME DOMAIN AND FREQUENCY DOMAIN ANALYSIS 9

TIME DOMAIN ANALYSIS : Standard test inputs – Time responses – Time domain specifications – Stability analysis: Concept of stability

FREQUENCY DOMAIN ANALYSIS Bode plot, – Frequency domain specifications Introduction to closed loop Frequency Response. Effect of adding lag and lead compensators.

UNIT III DESIGN OF FEED BACK CONTROL SYSTEM 9

Design specifications – Lead, Lag and Lag-lead compensators using Root locus and Bode plot techniques –PID controller. - PID control in State Feedback form.

UNIT IV CONVERTER DYNAMICS 9

AC equivalent circuit analysis – State space averaging – Circuit averaging – Averaged switch modeling – Transfer function model for buck, boost, buck-boost and cuk converters – Input filters.

UNIT V CONTROLLER DESIGN 9

Review of P, PI, and PID control concepts – gain margin and phase margin – Bode plot based analysis – Design of controller for buck, boost and buck-boost converters.

TOTAL : 45 PERIODS

TEXT BOOKS:

1. BenjaminC.Ku and Farid Golnaraghi,“Automatic Control Systems”,10th edition McGraw-Hill Education,2017.
2. Nagrath,I.J. and Gopal,M., “Control Systems Engineering”, 6th edition New Age International Publishers 2017.
3. Graham C.Goodwin, StefanF.Graebe, MarioE.Salgado, “Control System Design”, 2002.

REFERENCES:

1. Hebertt Sira-Ramírez and Ramón Silva-Ortigoza,”Control Design Techniques in Power Electronics Devices “ Springer-Verlag London Limited 2006
2. Katsuhiko Ogata,“Modern Control Engineering”, PHI Learning Private Ltd, PEARSON, 5th Edition, 2015.
3. Robert W. Erickson & Dragon Maksimovic, ” Fundamentals of Power Electronics”, Second Edition, 2001 Springer science and Business media
4 Ned Mohan, “Power Electronics: A first course”, John Wiley,2012.
5 Marian K. Kazimierczuk and Agasthya Ayachit,”Laboratory Manual for Pulse-Width Modulated DC–DC Power Converters”, Wiley 2016
6 Farzin Asadi and Kei Eguchi, Morgan &Claypool,”Dynamics and Control of DC-DC Converters”, 2018
7 Andre Kislovski, “Dynamic Analysis of Switching-Mode DC/DC Converters” ,Springer 1991

EE23043 ELECTRIC VEHICLE ARCHITECTURE L T P C
3 0 0 3

UNIT I VEHICLE ARCHITECTURE AND SIZING 7

Electric Vehicle History, and Evolution of Electric Vehicles. Series, Parallel and Series parallel Architecture, Micro and Mild architectures. Mountain Bike - Motorcycle- Electric Cars and Heavy Duty EVs. -Details and Specifications.

UNIT II VEHICLE MECHANICS 7

Vehicle mechanics- Roadway fundamentals, Laws of motion, Vehicle Kinetics, Dynamics of vehicle motion, propulsion power, velocity and acceleration, Tire –Road mechanics, Propulsion System Design.

UNIT III POWER COMPONENTS AND BRAKES 7

Power train Component sizing- Gears, Clutches, Differential, Transmission and Vehicle Brakes. EV power train sizing, HEV Powertrain sizing, Example.

UNIT IV HYBRID VEHICLE CONTROL STRATEGY 7

Vehicle supervisory control, Mode selection strategy, Modal Control strategies.

UNIT V PLUG-IN HYBRID ELECTRIC VEHICLE 7

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

SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / etc) Basics of MATLAB simulation 10

1. Variables and Expressions Formats,
2. Arrays, Vectors,
3. Matrices, Built-in functions, Trigonometric functions,
4. Data types and Plotting,
5. Simulation of drive cycles.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, students will be able to:
CO1 Summarize the History and Evolution of EVs, Hybrid and Plug-In Hybrid EVs
CO2 Describe the various EV components
CO3 Describe the concepts related in the Plug-In Hybrid Electric Vehicles
CO4 Analyse the details and Specifications for the various EVs developed
CO5 Describe the hybrid vehicle control strategy

REFERENCES:

1. Mehrdad Ehsani, YiminGao, Sebastian E. Gay, Ali Emadi, 'Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design', CRC Press, 2004.
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.
4. 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.
5. Heavy-duty Electric Vehicles from Concept to Reality, Shashank Arora, Alireza Tashakori Abkenar, Shantha Gamini Jayasinghe, Kari Tammi, Elsevier Science, 2021.
6. Electric Vehicles Modern Technologies and Trends, Nil Patel, Akash Kumar Bhoi, Sanjeevikumar Padmanaban, Jens Bo Holm-Nielsen Springer, 2020.
7. Hybrid Electric Vehicles: A Review of Existing Configurations and Thermodynamic Cycles, Rogelio León , Christian Montaleza , José Luis Maldonado , Marcos Tostado-Véliz and Francisco Jurado, Thermo, 2021.

Mapping COs and POs:

COs	POs												PSOs			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	-	2	-	-	-	-	1	-	-	-	2	3	-	-	1
CO2	3	-	2	-	-	-	-	1	-	-	-	2	3	3	3	3
CO3	3	-	2	-	-	-	-	1	-	-	-	2	3	-	-	3
CO4	3	-	2	-	-	-	-	1	-	-	-	2	3	-	-	3
CO5	3	-	3	3	3	-	-	1	-	-	-	2	3	3	3	3
Avg	3	-	2.2	3	3	-	-	1	-	-	-	2	3	3	3	2.6

EE23044 DESIGN OF HYBRID ELECTRIC VEHICLES LT P C
3 0 0 3

UNIT I INTRODUCTION TO HYBRID ELECTRIC VEHICLE 9

History of Hybrid Electric Vehicles, Architectures of HEVs, Interdisciplinary Nature of HEVs, State of the Art of HEVs, Challenges and Key Technology of HEVs. Basics of the EV, Basics of the HEV, Basics of Plug-In Hybrid Electric Vehicle (PHEV), Basics of Fuel Cell Vehicles (FCVs).

UNIT II POWER ELECTRONIC IN HYBRID ELECTRIC VEHICLE 9

Hybrid Vehicle Model, Vehicle Performance, EV Powertrain Component Sizing, Series Hybrid Vehicle, Parallel Hybrid Vehicle, Wheel Slip Dynamics. Plug-in HEVs Architectures, Fuel Economy of PHEVs, Power Management of PHEVs, Component Sizing of EREVs, Vehicle-to-Grid Technology.

Power electronics including switching, AC-DC, DC-AC conversion, electronic devices and circuits used for control and distribution of electric power, Thermal Management of HEV Power Electronics.

UNIT III BATTERIES, CAPACITORS, FUEL CELLS AND CONTROLS 9

Introduction to Batteries, capacitors, fuel cells and controls, Different types of batteries, Battery Characterization, Comparison of Different Energy Storage Technologies for HEVs, Battery Charging Control, Charge Management of Storage Devices, Flywheel Energy Storage System, Hydraulic Energy Storage System, Fuel Cells and Hybrid Fuel Cell Energy Storage System and Battery Management System.

UNIT IV ELECTRIC MACHINES AND DRIVES IN HEVS 9

Types of Motors- DC motors- AC motors, BLDC motors, Induction Motor Drives, Permanent Magnet Motor Drives, Switched Reluctance Motors, Doubly Salient Permanent Magnet Machines, Design and Sizing of Traction Motors, Thermal Analysis and Modelling of Traction Motors.

UNIT V MODELLING OF HEVs AND ENERGY MANAGEMENT STRATEGIES 9

Driving Cycles, Types of Driving Cycles, Range modeling for Battery Electric Vehicle, Hybrid (ICE & others), Fuel Cell EV, and Solar Powered Vehicles. Case study of 2 wheeler, 3 wheeler and 4 wheeler vehicles.

Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

CO1 Understand the history, architecture, challenges and key technologies of hybrid electric vehicles
CO2 Explain the role of power electronics in hybrid electric vehicles
CO3 Identify various energy source involved in HEVs like battery and fuel cell
CO4 Select suitable electric motor for applications in hybrid electric vehicles.
CO5 Explain the HEVs modeling and study the energy management strategies for hybrid electric vehicles.

TEXT BOOKS:

1. Iqbal Husain, " Electric and Hybrid Vehicles-Design Fundamentals", CRC Press,2003
2. Mehrdad Ehsani, " Modern Electric, Hybrid Electric and Fuel Cell Vehicles", CRC Press,2005

REFERENCES:

1. James Larminie and John Lowry, "Electric Vehicle Technology Explained " John Wiley & Sons,2003
2. Lino Guzzella, " Vehicle Propulsion System" Springer Publications,2005
3. Ron HodKinson, "Light Weight Electric/ Hybrid Vehicle Design", Butterworth Heinemann Publication,2005

COs	POs												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	3	3	3	2	2	2	1	2			2	2		2
2	3	3	3	3	2	2	2	1	2			2	2		2
3	3	3	3	3	2	2	2	1	2			2	2		2
4	3	3	3	3	2	2	2	1	2			2	2		2
5	3	3	3	3	2	2	2	1	2			2	2		2

EE23045	ENERGY STORAGE DEVICES FOR HYBRID ELECTRIC VEHICLES	L	T	P	C
		3	0	0	3

UNIT I OVERVIEW OF ENERGY STORAGE TECHNOLOGIES 9

Introduction, Necessity for energy storage, Classification of energy storage systems, Overview of various energy storage technologies, Comparison of energy storage technologies

UNIT II THERMAL ENERGY STORAGE 9

Introduction, Types – Sensible, Latent and Thermochemical heat storage principle, Materials used in thermal energy storage systems – Organic, Inorganic and PCMs, Applications – Domestic, Industrial process heating and Solar thermal power plants, Advantages, and limitations.

UNIT III ELECTRICAL ENERGY STORAGE 9

Introduction, Types – Electrochemical and Capacitive systems, Working principle and characteristics of different batteries (lead-acid, lithium-ion and nickel-metal hydride) and capacitive storage systems (supercapacitors and electric double-layer capacitors), Applications - renewable energy integration, electric vehicles, and grid-scale energy storage systems, energy recovery systems, and power quality improvement.

UNIT IV CHEMICAL ENERGY STORAGE 9

Introduction, Fuel cells – Proton exchange membrane and Solid oxide fuel cells – Working principles and electrochemical reactions – Materials – Advantages and limitations – Applications, Hydrogen storage – Compressed, liquid and metal hydride storage – Working principle and storage mechanism – Materials – Advantages and limitations – Applications.

UNIT V HYBRID ENERGY STORAGE SYSTEMS 9

Overview, Types – Combined electrochemical and capacitive storage, thermal and electrochemical, Working principle and integration of different storage technologies, Advantages and limitations, Applications – Microgrids, electric vehicles, renewable energy integration.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, the students will be able to understand

- **CO1** Understand the concept of energy storage and its importance in various fields.
- **CO2** Discuss the working and potential applications of thermal energy storage systems in various fields.
- **CO3** Elaborate the working and study the characteristics of different batteries.
- **CO4** Understand the working principle of fuel cell and hydrogen storage technologies.
- **CO5** Choose appropriate hybrid energy technology for various applications.

TEXT BOOKS:

1. A. R. Pendse, “Energy Storage Science and Technology”, SBS Publishers & Distributors Pvt. Ltd., New Delhi, 2011.
2. Ibrahim Dincer and Mark A. Rosen, “Thermal Energy Storage Systems and Applications”, John Wiley & Sons, 3rd Edition, 2021.

REFERENCES:

1. Ru-shi Liu, Lei Zhang and Xueliang sun, “Electrochemical technologies for energy storage and conversion”, Wiley publications, 2012.
2. Robert A. Huggins, “Energy Storage – Fundamentals, materials and applications”, Springer, 2nd Edition, 2016
3. A.G.Ter-Gazarian, “Energy Storage for Power Systems”, The Institution of Engineering and Technology (IET) Publication, UK, 2nd Edition, 2011.

Mapping COs and POs:

COs	POs												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	2	1	-	-	-	-	1	-	-	-		-	1	-	-
2	2	1	1	-	-	-	1	-	1	-	1	-	1	-	1
3	2	1	1	-	-	-	1	-	1	-	1	-	1	-	1
4	2	1	1	-	-	-	1	-	1	-	1	-	1	-	1
5	2	1	1	-	-	-	1	-	1	-	1	-	1	-	1
Avg.	2	1	1	-	-	-	1	-	1	-	1	-	1	-	1

EE23046 ELECTRIC VEHICLE CHARGING SYSTEMS L T P C
3 0 0 3

UNIT I ELECTRIC VEHICLES AND VEHICLE MECHANICS 9

Electric Vehicles (EV), Hybrid Electric Vehicles (HEV), Engine ratings- Comparisons of EV with internal combustion Engine vehicles- Fundamentals of vehicle mechanics.

UNIT II CHARGING STATIONS AND STANDARDS 9

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

UNIT III EV CHARGING USING RENEWABLE AND STORAGE SYSTEMS 9

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

UNIT IV WIRELESS POWER TRANSFER 9

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 POWER FACTOR CORRECTION IN CHARGING SYSTEM 9

Need for power factor correction- Boost Converter for Power Factor Correction, Sizing the Boost Inductor, Average Currents in the Rectifier and calculation of power losses.

TOTAL :45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, students will be able to:
CO1: describe the concepts related with EV, HEV.
CO2: Understand the electric vehicle charging mechanism. .
CO3: Learn the concepts of Charging using renewable energy storage systems. .
CO4: explain the concepts related with wireless charging systems.
CO5: perform power factor correction in charging system.

REFERENCES:

1. Electric and Hybrid Vehicles, Design Fundamentals, Third Edition, Iqbal Husain, CRC Press, 2021.
2. Ali Emadi, Mehrdad Ehsani, John M.Miller, “Vehicular Electric Power Systems”, Special Indian Edition, Marcel dekker, Inc 2003, 1st Edition.
3. Wie Liu, “Hybrid Electric Vehicle System Modeling and Control”, Second Edition, John Wiley & Sons, 2017, 2nd Edition.
4. Mobile Electric Vehicles Online Charging and Discharging, Miao Wang Ran Zhang Xuemin (Sherman) Shen, Springer 2016, 1st Edition.
5. Alicia Triviño-Cabrera, José M. González-González, José A. Aguado, Wireless Power Transferor Electric Vehicles: Foundations and Design Approach, Springer Publisher 1st Edition. 2020.
6. Nil Patel, Akash Kumar Bhoi, Sanjeevikumar Padmanaban, Jens Bo Holm-Nielsen, Electric

Vehicles Modern Technologies and Trends. Springer Publisher 1st Edition, 2021.
7. 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, 1st Edition.

MAPPING OF COs WITH POs AND PSOs

COs	POs												PSOs			
	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	3	3	3	-	-	-	1	2	-	2	-	-	-	-
CO2	3	3	3	3	3	-	-	-	1	3	-	2	-	-	-	-
CO3	3	3	3	3	3	-	3	-	1	2	-	2	-	-	-	-
CO4	3	3	3	3	3	-	3	-	1	2	-	2	-	-	-	-
CO5	3	3	3	3	3	-	3	-	1	2	-	2	-	-	-	-
Avg	3	3	3	3	3	-	3	-	1	2.3	-	2	-	-	-	-