NATIONAL ENGINEERING COLLEGE

(An Autonomous Institution Affiliated to Anna University Chennai)

K.R.NAGAR, KOVILPATTI

www.nec.edu.in

REGULATIONS – 2023

CURRICULUM & SYLLABUS

B. E. – ELECTRICAL AND ELECTRONICS ENGINEERING

(Outcome Based Education & Choice Based Credit System)

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

I. VISION

- Promoting active learning, critical thinking coupled with ethical values to meet the global challenges

II. MISSION

- To instill state-of-the-art technical knowledge and research capability that will prepare our graduates for professionalism and life-long learning.
- To update knowledge to meet industrial and real world challenges
- To inculcate social and ethical values.

III. PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO 1 : Excel in industrial or graduate work in Electrical Engineering and allied fields.

PEO 2 : Practice their profession conforming to ethical values and active participation in the affairs of the profession.

PEO 3 : Adapt to evolving technologies and stay current with their profession

IV. PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO 1 : Apply the basic knowledge of mathematics, science and engineering to identify, formulate, design and investigate complex engineering problems of power electronics and drives, power and energy systems, high voltage engineering, control and instrumentation and applied electronics.

PSO 2 : Apply the modern engineering hardware and software tools in electrical and electronics engineering to adopt in multi disciplinary environments and innovative practices.

V. PROGRAM OUTCOMES (POs)

PO 1: Engineering Knowledge: Apply knowledge of mathematics, natural science, computing, and engineering fundamentals, and an engineering specialization to develop solutions to complex engineering problems

PO 2: Problem Analysis: Identity, formulate, research literature, and analyze complex engineering problems, reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences with holistic considerations for sustainable development

PO 3: Design / development of solutions: Design creative solutions for complex engineering problems and design systems, components, or processes to meet identified needs with appropriate consideration for public health and safety, whole-life cost, net zero carbon, as well as resource, cultural, societal, and environmental considerations as required

PO 4: Investigation: Conduct investigations of complex engineering problems using research methods, including research-based knowledge, design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions

PO 5 : Tool Usage: Create, select and apply, and recognize limitations of appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering problems

PO 6: The Engineer and the World: When solving complex engineering problems, analyze and evaluate sustainable development impacts* to society, the economy, sustainability, health and safety, legal frameworks, and the environment

PO 7: Ethics: Apply ethical principles and commit to professional ethics and norms of engineering practice and adhere to relevant national and international laws. Demonstrate an understanding of the need for diversity and inclusion

PO 8: Individual and Collaborative Team work: Function effectively as an individual and as a member or leader in diverse and inclusive teams and in multidisciplinary, face-to-face, remote, and distributed settings

PO 9: Communication: Communicate effectively and inclusively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, taking into account cultural, language, and learning differences.

PO 10: .Project Management and Finance: Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.

PO 11: Lifelong learning: Recognize the need for and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change

REGULATIONS 2023

B.E. – EEE CURRICULUM AND SYLLABUS

SEMESTER – I

S. No	Course Code	Course Title	Category	Periods Per Week				Total Contact Periods	Credits
				L	T	P	E		
Induction Programme – 2 weeks									**0**
Theory Courses									
1.	23SH11C	தமிழர் மரபு / Heritage of Tamils	HSMC	1	0	0	0	1	1
2.	23SH12C	Mathematical Foundations for Engineers	BSC	3	1	0	0	4	4
3.	23SH13C	Introduction to Engineering	ESC	1	0	0	0	1	1
Integrated Courses									
4.	23SH14C	Technical English	HSMC	1	0	2	0	3	2
5.	23SH15C	Engineering Physics	BSC	2	0	2	0	4	3
6.	23SH16C	Engineering Chemistry	BSC	2	0	2	0	4	3
7.	23ME11C	Engineering Graphics	ESC	2	0	4	0	6	4
Practical Courses									
8.	23EE14C	Engineering Practice	ESC	0	0	4	0	4	2
			TOTAL	**12**	**1**	**14**	**0**	**27**	**20**

SEMESTER - II

S. No	Course Code	Course Title	Category	Periods Per Week				Total Contact Periods	Credits
				L	T	P	E		
Theory Courses									
1.	23SH21C	தமிழரும் தொழில்நுட்பமும் / Tamils and Technology	HSMC	1	0	0	0	1	1
2.	23GN05C	Professional Ethics and Human Values	HSMC	2	0	0	0	2	2
3.	23GN01C	Aptitude Essentials	EEC	1	0	0	0	1	1
4.	23EE21C	Fourier Series & Transform, Complex Analysis and Calculus	BSC	3	1	0	0	4	4
5.	23EE22C /23EC22C	Materials Science	ESC	2	0	0	0	2	2
6.	23EE23C	Basic Civil and Mechanical Engineering	ESC	3	0	0	0	3	3
Integrated Courses									
7.	23EE24C	Electric Circuit Analysis	PCC	3	1	2	0	6	5
8.	23SH22C	Professional English	HSMC	1	0	2	0	3	2
9.	23CS11C	Problem Solving Techniques	ESC	3	0	2	0	5	4
Practical Courses									
10.	23GN02C	Innovation through Design Thinking	EEC	0	0	0	4	4	2
			TOTAL	**19**	**2**	**6**	**4**	**31**	**26**

SEMESTER – III

S. No	Course Code	Course Title	Category	Periods Per Week				Total Contact Periods	Credits
				L	T	P	E		
Theory Courses									
1.	23EE31C	Electromagnetic Theory	ESC	3	1	0	0	4	4
Integrated Courses									
2.	23EE32C	Transforms, Probability and Statistics	BSC	3	1	0	0	4	4
3.	23EE33C	DC Machines and Transformers	PCC	3	0	2	0	5	4
4.	23EE34C	Measurement and Instrumentation	PCC	3	0	2	0	5	4
5.	23EE35C	Electron Devices and Circuits	PCC	3	1	2	0	6	5
Practical Courses									
6.	23GN03C	Intellectual Property Rights Study	EEC	0	0	0	4	4	2
7.	23GN04C	Aptitude Excellence	EEC	0	0	2	0	2	1
			TOTAL	**15**	**3**	**8**	**4**	**30**	**24**

SEMESTER – IV

S. No	Course Code	Course Title	Category	Periods Per Week				Total Contact Periods	Credits
				L	T	P	E		
Theory Courses									
1.	23EE41C	Signals and Systems	PCC	3	0	0	0	3	3
2.	23EE42C	Power System-I	PCC	3	1	0	0	4	4
3.	-	Elective Science Stream	BSC	3	0	0	0	3	3
4.	23MC02C	Environmental Science and Engineering	MC	2	0	0	0	2	0
Integrated Courses									
5.	23EE43C	AC Rotating Machines	PCC	3	0	2	0	5	4
6.	23EE44C	Linear Integrated Circuits	PCC	3	1	2	0	6	5
7.	23EE45C	Digital Electronics	ESC	3	1	2	0	6	5
Practical Courses									
8.	23EE46C	System Modeling projects	EEC	0	0	2	2	4	2
			TOTAL	**20**	**3**	**8**	**2**	**33**	**26**

SEMESTER – V

S. No	Course Code	Course Title	Category	Periods Per Week				Total Contact Periods	Credits
				L	T	P	E		
Theory Courses									
1.	-	PEC I	PEC	3	0	0	0	3	3
2.	-	OEC I	OEC	3	0	0	0	3	3
3.	23MC01C	Constitution of India	MC	2	0	0	0	2	0
Integrated Courses									
4.	23EE51C	Control Systems	PCC	3	0	2	0	5	4
5.	23EE52C	Power System II	PCC	3	0	2	0	5	4
6.	23EE53C	Microprocessor, Microcontroller and its Applications	PCC	3	0	2	0	5	4
7.	23EE54C	Power Electronics	PCC	3	0	2	0	5	4
Practical Courses									
8.	23EE55C	Simulation using Modern tools	EEC	0	0	2	2	4	2
			TOTAL	**20**	**0**	**10**	**2**	**32**	**24**

SEMESTER – VI

S. No	Course Code	Course Title	Category	Periods Per Week				Total Contact Periods	Credits
				L	T	P	E		
Theory Courses									
1.	23EE61C	Power System Protection and Switchgear	PCC	3	0	0	0	3	3
2.	23EEXXE	PEC II	PEC	3	0	0	0	3	3
3.	23EEXXE	PEC III	PEC	3	0	0	0	3	3
4.	-	OEC II	OEC	3	0	0	0	3	3
5.	23GN06C	Project Management and Finance	HSMC	2	0	0	0	2	2
Integrated Courses									
6.	23EE62C	High Voltage Engineering	PCC	3	0	2	0	5	4
7.	23EE63C	Object Oriented Programming	ESC	2	0	2	2	6	4
Practical Courses									
8.	23EE64C	Product Development Practice	EEC	0	0	0	4	4	2
			TOTAL	**19**	**0**	**4**	**6**	**29**	**24**

SEMESTER – VII

S. No	Course Code	Course Title	Category	Periods Per Week				Total Contact Periods	Credits
				L	T	P	E		
Theory Courses									
1.	-	PEC IV	PEC	3	0	0	0	3	3
2.	-	PEC V	PEC	3	0	0	0	3	3
3.	-	PEC VI	PEC	3	0	0	0	3	3
4.	-	OEC III	OEC	3	0	0	0	3	3
Practical Courses									
5.	23EE71C	Mini Project	EEC	0	0	0	6	6	3
6.	23EE72C	Internship (4 Weeks)	EEC	-	-	-	-	-	2
			TOTAL	**12**	**0**	**0**	**6**	**18**	**17**

SEMESTER – VIII

S. No	Course Code	Course Title	Category	Periods Per Week				Total Contact Periods	Credits
				L	T	P	E		
Practical Courses									
1.	23EE81C	Capstone Project / Industry Practice	EEC	0	0	0	12	12	6
			TOTAL	**0**	**0**	**0**	**12**	**12**	**6**

Total Number of credits: 167

DISTRIBUTION OF CREDIT – EEE DEPARTMENT

Category	I Sem.	II Sem.	III Sem.	IV Sem.	V Sem.	VI Sem.	VII Sem.	VIII Sem.	Credits	Percentage of credits
HSMC	3	5	-	-	-	2	-	-	**10**	05.99
BSC	10	4	4	3	-	-	-	-	**21**	12.58
ESC	7	9	4		-	4	-	-	**24**	14.38
PCC	-	5	13	21	16	7	-	-	**62**	37.12
PEC	-	-	-	-	3	6	9	-	**18**	10.77
OEC	-	-	-	-	3	3	3	-	**9**	05.38
EEC	-	3	3	2	2	2	5	6	**23**	13.78
Total	**20**	**26**	**24**	**26**	**24**	**24**	**17**	**6**	**167**	**100**

VERTICALS AND PROGRAME ELECTIVE COURSES (PEC)

S. No	Course Category	Course Code	Course Name	L	T	P	E	C
ELECTRIC VEHICLE TECHNOLOGY								
1.	PEC	23EE01E	Autonomous Intelligent Vehicles	3	0	0	0	3
2.	PEC	23EE02E	Automotive Electrical and Electronics	3	0	0	0	3
3.	PEC	23EE03E	Electric Vehicle safety	3	0	0	0	3
4.	PEC	23EE04E	Battery Management systems and Modeling	3	0	0	0	3
5.	PEC	23EE05E	Electric Vehicle Machines and Drives	3	0	0	0	3
6.	PEC	23EE06E	Electric Vehicle dynamics.	3	0	0	0	3
7.	PEC	23EE07E	Control of Hybrid Electric Vehicles	3	0	0	0	3
8.	PEC	23EE08E	Grid Integration of Electric Vehicles	3	0	0	0	3
9.	PEC	23EE09L	Design of Power Converters Laboratory	0	0	2	0	1
10.	PEC	23EE10L	EV Battery Design and Modeling Laboratory	0	0	2	0	1
11.	PEC	23EE11L	Electric Vehicles Simulation Laboratory	0	0	2	0	1
12.	PEC	23EE12L	Autonomous Vehicle sensors.	1	0	0	0	1
HIGH VOLTAGE ENGINEERING								
13.	PEC	23EE09E	Insulation Technology	3	0	0	0	3
14.	PEC	23EE10E	Sustainable and Environmental Friendly HV Insulation System	3	0	0	0	3
15.	PEC	23EE11E	EHV Power Transmission	3	0	0	0	3
16.	PEC	23EE12E	HVDC Transmission Systems	3	0	0	0	3
17.	PEC	23EE13E	High Voltage Switchgear	3	0	0	0	3
18.	PEC	23EE14E	Condition Monitoring of High Voltage Power Equipment	3	0	0	0	3
19.	PEC	23EE13L	Insulation Coordination	1	0	0	0	1
20.	PEC	23EE14L	Alternate insulating medium	1	0	0	0	1
21.	PEC	23EE15L	High Voltage Testing Techniques	0	0	2	0	1
DIVERSIFIED								
22.	PEC	23EE15E	Energy Storage Systems and Application	3	0	0	0	3
23.	PEC	23EE16E	Thermal Management for Electrical and Electronics Engineering	3	0	0	0	3
24.	PEC	23EE17E	Machine Learning for Electrical Engineering	3	0	0	0	3
25.	PEC	23EE18E	Microcontroller based System Design	3	0	0	0	3
26.	PEC	23EE19E	Digital Signal Processing	3	0	0	0	3
27.	PEC	23EE20E	Advanced CMOS Microfabrication	3	0	0	0	3
28.	PEC	23EE21E	VLSI Design	3	0	0	0	3
29.	PEC	23EE22E	Special Machines and Drives	3	0	0	0	3
30.	PEC	23EE23E	Wind and Solar Energy Systems	3	0	0	0	3
31.	PEC	23EE24E	Electrical Machine Design	3	0	0	0	3
32.	PEC	23EE25E	Power Electronics Applications to Power Systems	3	0	0	0	3
33.	PEC	23EE26E	Solid State Drives	3	0	0	0	3
34.	PEC	23EE27E	Switched Mode Power Conversions	3	0	0	0	3
35.	PEC	23EE28E	Power Electronics for Renewable Energy Systems	3	0	0	0	3
36.	PEC	23EE29E	Design of Photovoltaic Systems	3	0	0	0	3

S. No	Course Category	Course Code	Course Name	L	T	P	E	C
37.	PEC	23EE30E	Electronics Design and Technology	3	0	0	0	3
38.	PEC	23EE31E	Logic and Distributed Control System	3	0	0	0	3
39.	PEC	23EE32E	Intelligent Sensors and Instrumentation	3	0	0	0	3
40.	PEC	23EE33E	Advanced Control Theory	3	0	0	0	3
41.	PEC	23EE34E	Substation Automation	3	0	0	0	3
42.	PEC	23EE35E	Mobile Robotics and Control	3	0	0	0	3
43.	PEC	23EE36E	Robotics and Automation	3	0	0	0	3
44.	PEC	23EE37E	MEMS and NEMS	3	0	0	0	3
45.	PEC	23EE38E	Big Data Analytics for Smart Grid	3	0	0	0	3
46.	PEC	23EE39E	Power Quality	3	0	0	0	3
~~47.~~	PEC	23EE40E	Energy Auditing and Conservation	3	0	0	0	3
48.	PEC	23EE41E	Electrical Safety, Operations, Regulations	3	0	0	0	3
49.	PEC	23EE42E	Electric Power Stations	3	0	0	0	3
50.	PEC	23EE43E	Sustainable Power Generation Systems	3	0	0	0	3
51.	PEC	23EE44E	Utilization of Electrical Energy	3	0	0	0	3
52.	PEC	23EE45E	Smart Grid	3	0	0	0	3
53.	PEC	23EE46E	Embedded Systems	3	0	0	0	3

ONE CREDIT COURSES (PEC)

S. No	Course Category	Course Code	Course Name	L	T	P	E	C
1.	PEC	23EE01L	ARDUINO and ESP8266 Programming	0	0	2	0	1
2.	PEC	23EE02L	PCB Design and Fabrication	0	0	2	0	1
3.	PEC	23EE03L	ARM Architecture and Micropython	0	0	2	0	1
4.	PEC	23EE04L	Thermal Power Plants – Equipments, Operation And Control	1	0	0	0	1
5.	PEC	23EE05L	Nuclear Power Plants – – Equipments, Operation And Control	1	0	0	0	1
6.	PEC	23EE06L	Quality Practices For Safety Critical Instrumentation System	1	0	0	0	1
7.	PEC	23EE07L	Hydrogen Energy And Fuel Cells	1	0	0	0	1
8.	PEC	23EE08L	VLSI Design Laboratory	0	0	2	0	1

ELECTIVE COURSES (SCIENCE STREAM)

S. No	Course Category	Course Code	Course Name	L	T	P	E	C
MATHEMATICS								
1.	OEC	23SH01E	Linear Algebra, Mathematical Logic and Set Theory	2	1	0	0	3
2.	OEC	23SH02E	Linear Structures and Transformations	2	1	0	0	3
3.	OEC	23SH03E	Number Theory	2	1	0	0	3
4.	OEC	23SH04E	Numerical Analysis	2	1	0	0	3
5.	OEC	23SH05E	Optimization Techniques	2	1	0	0	3
6.	OEC	23SH06E	Principles of Discrete Mathematics	2	1	0	0	3
7.	OEC	23SH07E	Random Processes and Queuing Theory	2	1	0	0	3
8.	OEC	23SH08E	Statistical Techniques and Numerical Methods	2	1	0	0	3
9.	OEC	23SH09E	Transforms, Mathematical Logic and Set Theory	2	1	0	0	3
PHYSICS								
10.	OEC	23SH10E	Fundamentals of Laser Technology	3	0	0	0	3
11.	OEC	23SH11E	Nanomaterials for Engineers	3	0	0	0	3
12.	OEC	23SH12E	Photonics	3	0	0	0	3
CHEMISTRY								
13.	OEC	23SH13E	Biology for Computing	3	0	0	0	3
14.	OEC	23SH14E	Biological Systems for Engineers	3	0	0	0	3
15.	OEC	23SH15E	Polymer Science and Technology	3	0	0	0	3
16.	OEC	23SH16E	Sensors for Engineering Applications	3	0	0	0	3

Course Code	**தமிழர் மரபு (HERITAGE OF TAMILS)**	**L**	**T**	**P**	**E**	**C**
23SH11C	(Common to all B.E. / B.Tech. Degree Programmes)	**1**	**0**	**0**	**0**	**1**

COURSE OUTCOMES

இப்பாடம் முடிந்ததும் மாணவர்களிடம் வளரும் திறன்

CO1: தமிழ் மொழியின் இலக்கிய வளம், ஓவிய, சிற்பக் கலையின் பரிணாம வளர்ச்சி நாட்டுப்புறக் கலை மற்றும் வீர விளையாட்டுக்கள் பற்றிய அறிவு மற்றும் விளக்கும் திறன்

CO2: தமிழர்களின் திணை சார் கோட்பாடுகள் மற்றும் இந்திய பண்பாட்டில் தமிழர்களின் பங்கு பற்றிய அறிவு மற்றும் விளக்கும் திறன்

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

Theory Component

CO1: know and explain about Tamil literary resources, Dimensional growth of painting and sculpture arts, folk art and martial arts.

CO2: know and explain about Tamils Thinai concepts, contribution of Tamils in Indian National Movements and Indian Culture

CO1: தமிழ் மொழியின் இலக்கிய வளம், ஓவிய, சிற்பக் கலையின் பரிணாம வளர்ச்சி நாட்டுப்புறக்கலை மற்றும் வீர விளையாட்டுக்கள் பற்றிய அறிவு மற்றும் விளக்கும் திறன் **L:9**

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

CO1: know and explain about Tamil literary resources, Dimensional growth of painting and sculpture arts, folk art and martial arts.

Language Families in India - Dravidian Languages – Tamil as a Classical Language – Classical Literature in Tamil – Secular Nature of Sangam Literature – Distributive Justice in Sangam Literature - Management Principles in Thirukural - Tamil Epics and Impact of Buddhism & Jainism in Tamil Land - Bakthi Literature Azhwars and Nayanmars - Forms of minor Poetry - Development of Modern literature in Tamil - Contribution of Bharathiyar and Bharathidhasan - 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 - Therukoothu, Karagattam, Villu Pattu, Kaniyan Koothu, Oyillattam, Leather puppetry, Silambattam, Valari, Tiger dance - Sports and Games of Tamils.

CO2:தமிழர்களின் திணை சார் கோட்பாடுகள் மற்றும் இந்திய பண்பாட்டில் தமிழர்களின் பங்கு பற்றிய அறிவு மற்றும் விளக்கும் திறன் **L:6**

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 - இந்திய விடுதலைப் போரில் தமிழர்களின் பங்கு - இந்தியாவின் பிறப்பகுதிகளில் தமிழ்ப் பண்பாட்டின் தாக்கம் - சுயமரியாதை இயக்கம் - இந்திய மருத்துவத்தில், சித்த மருத்துவத்தின் பங்கு – கல்வெட்டுகள், கையெழுத்துப் படிகள் - தமிழ்ப் புத்தகங்களின் அச்சு வரலாறு.

CO2: know and explain about Tamils Thinai concepts, contribution of Tamils in Indian National Movements and Indian Culture

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 - 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.

REFERENCES:

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

L: 15; TOTAL: 15 PERIODS

Course Code	MATHEMATICAL FOUNDATIONS FOR ENGINEERS	L	T	P	E	C
23SH12C	(Common to all B.E. / B.Tech. Degree Programmes)	3	1	0	0	4

COURSE OUTCOMES

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

Theory Component

CO1: interpret the nature of quadratic form by orthogonal transformation.
CO2: identify the maxima and minima of functions.
CO3: solve ordinary differential equations.
CO4: find the solution of partial differential equations.
CO5: evaluate integrals of multivariate calculus.

Soft skill Component

CO6 : develop communication, problem solving and interpersonal skills

CO1: interpret the nature of quadratic form by orthogonal transformation. **L:9, T:3**

Characteristic equation – Eigen values and Eigen vectors of a real matrix – Properties of Eigen values and Eigen vectors – Diagonalisation of a matrix by orthogonal transformation – Quadratic forms – Reduction of quadratic form to canonical form by orthogonal transformation and its nature; Cayley – Hamilton theorem (excluding proof) - Application: Stretching of a elastic membrane.

CO2: identify the maxima and minima of functions. **L:9, T:3**

Functions of two variables: Limit, continuity and partial derivatives; Total derivative, Jacobian, Taylor series- Application : Linearization of Non Linear systems using Taylor Series - Maxima and minima - Method of Lagrange multipliers.

CO3: solve ordinary differential equations. **L:9, T:3**

Solutions of first order ordinary differential equations - Equations solvable for ‘p’, equations solvable for ‘y’, equations solvable for ‘x’ - Solutions of higher order linear differential equations with constant coefficients – Cauchy’s and Legendre’s linear equations - Method of variation of parameters – Solution of simultaneous linear differential equation. Application RCL – circuit and Mass Spring System.

CO4: find the solution of partial differential equations. **L:9, T:3**

Formation of partial differential equations – Solutions of standard types of first order partial differential equations - Lagrange’s linear equations - Solutions of homogeneous and Non homogeneous linear partial differential equations of second and higher order with constant coefficient – Application - Shallow wave equations of first order PDE.

CO5 : evaluate integrals of multivariate calculus **L:9, T:3**

Double integration – Cartesian and polar coordinates - Change of order of integration - Change of variables - Cartesian to polar coordinates - Area as double integral - Triple integration - Cartesian and polar coordinates – Change of Variables- Cartesian to spherical and cylindrical coordinates. Application – Moments and centers of mass.

TEXT BOOKS:

1. Grewal.B.S., Higher Engineering Mathematics, Khanna Publications, 44th Edition, 2021.
2. James E. Gentle, Matrix Algebra, Springer International Publishing, 2nd Edition, 2017
3. Shanker Rao.G., Linear Albebra, WileyIndia, 1st Edition , 2017

REFERENCES:

1. Bali.N.P. and Manish Goyal, A Textbook of Engineering Mathematics, Laxmi Publications Private Limited, 10th Edition, 2016.
2. Erwin Kreyszig, Advanced Engineering Mathematics, Wiley India, 10th Edition, 2017.
3. Kenneth B. Howell, Ordinary Differential Equations, CRC Press, 2020.
4. James Strewart, Daniel Clegg, Saleem Watson, Essential Calculus Early Trancendentals, Cengage Learning, 9th Edition, 2021.
5. Nanda Kumar A.K, P.S.Datti: Raju .K.George , Ordinary Differential Equations, Cambridge University press, 2017.

L: 45; T: 15; TOTAL: 60 PERIODS

Course Code	INTRODUCTION TO ENGINEERING	L	T	P	E	C
23SH13C	(Common to all B.E. / B.Tech. Degree Programmes)	**1**	**0**	**0**	**0**	**1**

COURSE OUTCOMES

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

Theory Component

CO1: articulate the importance of Engineering and its role in society through OBE framework
CO2: identify and describe academic pathways towards career settlement

CO1: articulate the importance of Engineering and its role in society through OBE framework **L:9**

Engineering – An introduction, Classification of different Engineering Disciplines, Role of Engineers in Society. Graduate Attributes (GA), Program Specific Criteria (PSC)- Program Educational Objectives (PEO), Program Outcomes (PO), Course Outcomes (CO), Choice Based Credit System (CBCS), course categories, teaching and learning process, active and passive learning, project / problem based learning, different assessments process.

CO2: identify and describe academic pathways towards career settlement **L:6**

Curriculum, cafeteria curriculum and self learning big picture of the Program and the significance of each course in the undergraduate Engineering Program, Discuss the different career paths for an engineering graduate. Career objective, competency requirement.

Case study: Each student has to interact with alumni mentors/seniors/faculty members/surf the internet and present a career path that inspires him/her at the end of the course

REFERENCES:

1. Quamrul H. Mazumder Introduction to Engineering, An Assessment and Problem Solving Approach, CRC Press, 1st Edition, 2016.
2. Saeed Moaveni, "Engineering Fundamentals an Introduction to Engineering", Cengage Learning, USA, 4th Edition, 2011.

L: 15; TOTAL: 15 PERIODS

Course Code	TECHNICAL ENGLISH	L	T	P	E	C
23SH14C	(Common to all B.E. / B.Tech. Degree Programmes)	**1**	**0**	**2**	**0**	**2**

COURSE OUTCOMES

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

Theory Component

CO1: apply the fundamental grammar rules in writing

CO2: utilizing phonetic transcription for pronunciation

Practical Component

CO3: apply the basic language skills in various aspects of communication

CO4: utilize technical terms and phrases in specific contexts

CO5: develop the pronunciation skill through various language components

CO6: distinguish different writing forms and interpret text through divergent thinking

CO7: develop effective reports with grammatical and language components

Soft skill Component

CO8: develop communication, team spirit, creativity and time management

CO1: apply the fundamental grammar rules in writing **L:13, P:26**

Parts of Speech - Word Formation using Prefix and Suffix - Sentence formation (Kinds of Sentences) - Tenses (Present, Past & Future tense) – Concord

CO3: apply the basic language skills in various aspects of communication

Diary Writing - Greeting and Self Introduction

CO4: utilize technical terms and phrases in specific contexts

Technical terms and extended definition - Essay Writing (Argumentative Essay and Analytical Essay) - Situational phrases & Conversation - Formal Letter Writing (Permission & Requisition letters)

CO6: distinguish different writing forms and interpret text through divergent thinking

Picture Description, Introduction to Reading Techniques (Skimming, scanning, inferring, predicting, Reading and Reviewing a book (Sci – Fi), E Mail Writing

CO7: develop effective reports with grammatical and language components
Listening and responding to general information (Business context) - Report Writing (Types, Structure, and Stages of report writing) - Checklist

CO2: utilizing phonetic transcription for pronunciation **L:2, P:4**

Phonetics (Vowels & Consonants)

CO5: develop the pronunciation skill through various language components

Word Transformation from one form to another - Letter Writing (Informal) - Listening and responding to general information (General context)

TEXT BOOKS:

1. Paul V. Anderson, Technical Communication: A Reader - Centered Approach, Cengage Learning, 9th Edition, 2017.
2. Ravindra Nath Tiwari, Technical English-II, Shashwat Publication, 1st Edition, 2020.
3. Stephen D. Krashen, Principles and Practice in Second Language Acquisition. Pergamon, 1987.
4. Lester Kaufman and Jane Straus, The Blue Book of Grammar and Punctuation: An Easy-to Use Guide with Clear Rules, Real-World Examples, and Reproducible Quizzes, Wiley, 2021.
5. Wells H. G., The Time Machine, Penguin Classics, 2012.

REFERENCES:

1. Michael McCarthy, English Grammar: The Basics, Taylor & Francis, 2021.
2. Peter Lucantoni and Lydia Kellas, Cambridge IGCSE(TM) English as a Second Language Workbook, Cambridge University Press, 6th Edition, 2022.

L: 15; P: 30; TOTAL: 45 PERIODS

Course Code	ENGINEERING PHYSICS	L	T	P	E	C
23SH15C	(Common to all B.E. / B.Tech. Degree Programmes)	**2**	**0**	**2**	**0**	**3**

COURSE OUTCOMES:

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

Theory Components:

CO1: identify the structural properties of crystalline materials
CO2: comprehend and apply the concepts of centre of mass and elasticity
CO3: explain thermodynamic parameters and fundamental laws and their application in various processes
CO4: illustrate the applications of different lasers and optical fibers
CO5: interpret the quantum concepts, to illustrate the quantization of energy, and computation

Practical Components:

CO6: compare the mechanical properties of the materials due to bending and torsion
CO7: analyze thermal conductivity of different bad conducting materials
CO8: explore the light-matter interaction by the phenomenon of interference and diffraction and photoelectric effect

Soft skill Component:

CO9: develop the team spirit and communication skill through group activities

CO1: identify the structural properties of crystalline materials **L:10**

Crystalline and amorphous materials - unit cell - primitive cell - crystal systems, Bravais lattices - Miller indices – interplanar distance – Characteristics of SC, BCC, FCC, HCP structures - Bragg's law - X-ray diffraction and its applications - Synthesis of crystalline materials

CO2: comprehend and apply the concepts of centre of mass and elasticity **L:6,**
CO6: compare the mechanical properties of the materials due to bending and torsion **P:10**

Multi-particle dynamics - Introduction - Center of mass (CM) – CM of continuous bodies -

Introduction to rigid bodies - translation - rotation – moment of inertia – theorems of moment of inertia – Torsional pendulum.

Elasticity – Stress - strain diagram and its applications - Moduli of elasticity and its relation - bending of beams - Bending moment – cantilever - theory and experiment - Uniform bending - theory and experiment – Non Uniform bending - I-shaped girders

CO3: explain thermodynamic parameters and fundamental laws and their application in various processes **L:6, P:8**

CO7: analyse thermal conductivity of different bad conducting materials.

Laws of thermodynamics – Thermo dynamical processes – Introduction to heat transfer – conduction - convection and radiation – thermal conductivity of good conductor –Radial flow of heat - Spherical shell method and cylindrical shell method – Thermal conductivity of poor conductor- Lee's disc method– Applications - heat exchangers - refrigerators and ovens

CO4: illustrate the applications of different lasers and optical fibers **L:6, P:6**

CO8: explore the light-matter interaction by the phenomenon of Interference and diffraction and photoelectric effect

Lasers: Interaction of light with matter - Einstein coefficients and their relations – characteristics of laser - components of laser – Lasing action – Pumping methods – Types of Laser - Nd-YAG laser -semiconductor laser- Applications

Fiber optics: principle and classification of optical fibers – propagation of light in optical fiber - Numerical aperture and Acceptance angle – losses associated with optical fibers (Qualitative) – Fiber optic communication system - Applications - Displacement and pressure sensors – Endoscopy

CO5: interpret the quantum concepts, to illustrate the quantization of energy, and computation **L:6, P:2**

CO8: explore the light-matter interaction by the phenomenon of interference and diffraction and photoelectric effect

Planck's radiation law - de-Broglie hypothesis – Matter waves - Heisenberg's uncertainty principle – elementary proof – applications – Schrödinger's time-dependent and time-independent wave equation – physical significance of wave function – Introduction to quantum tunneling - applications - particle in a one-dimensional box – tunneling microscope – quantum confinement in 0D, 1D, 2D systems - quantum computation

TEXT BOOKS:

1. Avadhanulu M. N., Kshirsagar P.G and Arun Murthy T.V.S, A Text book of Engineering Physics, S.Chand & Co, 11th Edition, 2018.
2. Kleppner D and Kolenkow R. An Introduction to Mechanics. McGraw Hill Education (Indian Edition), 2017.
3. Kenneth S Krane, Modern Physics, Wiley, 4th Edition, 2021.

REFERENCES:

1. Wolfson R., Essential University Physics, Volume 1 & 2, Pearson Education, 2nd Indian Edition, 2009.
2. Hitendra K. Malik, A.K.Singh, Engineering Physics, McGraw Hill Education, 2nd Edition, 2017.
3. Kyungwon An, Fundamentals of Laser Physics, World Scientific Publishing Company, 2023
4. Halliday D, Resnick R and Walker J, Principles of Physics, Wiley, 12th Edition, 2021.

L: 30; P: 30; TOTAL: 60 PERIODS

Course Code	ENGINEERING CHEMISTRY	L	T	P	E	C
23SH16C	(Common to all B.E. / B.Tech. Degree Programmes)	**2**	**0**	**2**	**0**	**3**

COURSE OUTCOMES

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

Theory Component

CO1: explain the suitable water treatment technologies for domestic and industrial applications

CO2: apply the knowledge of corrosion to solve the industrial problems

CO3: describe the preparation, properties and their applications of smart materials in various sectors

CO4: describe the basic components and performance analysis of batteries

CO5: predict the mechanical, electrical and electronics properties of materials using various instrumentation techniques

Practical Component

CO6: estimate the amount of Ca^{2+}/ Mg^{2+}, alkalinity and Chloride ion present in the water sample.

CO7: quantify the amount of acid and metal ion in the given samples by different analytical techniques

Soft skill Component

CO8: develop interpersonal, work ethics and communications skills for career settlement

CO1: explain the suitable water treatment technologies for domestic and industrial applications

CO6: estimate the amount of Ca^{2+}/ Mg^{2+}, alkalinity and Chloride ion present in the water sample.

Introduction, sources and impurities in water, potable water specifications (as per WHO and BIS) - hardness-types-estimation of $Ca^{2+}$and Mg^{2+} ion in water by EDTA method. Alkalinity-types-determination of alkalinity of water -chronic daily intake - incremental life time risk - hazard quotient, hazard index, contamination factor - determination of chloride ion in water using Argentometric method-municipal water treatment- physical methods and chemical methods. Disinfection-internal conditioning - calgon and carbonate conditioning. Desalination-types-Reverse Osmosis (RO) process- Forward osmosis (FO) - electro dialysis - demineralization. **L:6, P:12**

CO2: apply the knowledge of corrosion to solve the industrial problems.

CO7: quantify the amount of acid and metal ion in the given samples by different analytical techniques

Corrosion – mechanism of dry and wet corrosion-forms of corrosion– galvanic corrosion and differential aeration corrosion, crevice corrosion, pitting corrosion, microbial corrosion-stress corrosion, intergranular corrosion - determination of rate of corrosion by weight loss method. **L:6, P:6**

Protection: cathodic protection, surface coatings, corrosion inhibitors. Corrosion of industrial components: corrosion and its control in power industries, automotive industries, chemical processing industries and marine industries.

CO3: describe the preparation, properties and their applications of smart materials in various sectors

Polymers: introduction - classification - functional polymers: electroluminescence polymer, biodegradable polymers, fire retardant polymer, thermo responsive polymer - piezo, ferro and pyroelectric polymer - nanocomposites: introduction, synthesis, properties & applications- synthesis of nanocomposites using sol-gel process **L:6**

CO4: describe the basic components and performance analysis of batteries

Introduction - components - operation principle - Lead acid – Nickel metal hydride batteries- Lithium ions batteries: Lithium polymer battery, Lithium sulphur battery - fabrication and performance evaluation- safety issues - battery management system - recycling of lithium batteries. **L:6**

CO5:predict the mechanical, electrical and electronics properties of materials using various instrumentation techniques

CO7: quantify the amount of acid and metal ion in the given samples by different analytical techniques.

Spectroscopy methods: Beer-Lambert's law and its limitations– UV-visible spectroscopy and IR spectroscopy – principle - instrumentation– applications. Estimation of copper. Electro analytical methods: potentiometric titration - Estimation of Fe^{2+} ion by potentiotometric method. Conductometric method- estimation of HCl by conductometric titration- pH metric method-Estimation of HCl by pH metric titration-applications. Thermal analytical methods: Thermal Gravimetric Analysis (TGA) and Differential Thermal Analysis (DTA)- Thermo Mechanical Analysis (TMA) –principle - instrumentation - Thermo gravimetric analysis of $CuSO_4.5H_2O$- applications. **L:6, P:12**

TEXT BOOKS:

1. Jain P.C. and Jain M, Engineering Chemistry, Dhanpat Rai Publishing Company, New Delhi, 17th Edition, 2021.
2. Dara S.S and Umare S.S, A Text Book of Engineering Chemistry, S.Chand & Company Limited, 20th Edition, 2018.
3. Agarwal S, Engineering Chemistry, Cambridge Publishing Company, 2nd Edition, 2019

REFERENCES:

1. Benjamin M. M, Water Chemistry, Waveland Press, 2nd Edition, 2019.
2. Cicek V, Corrosion Engineering, Springer Publishing, 1st Edition, 2021.
3. Shahinpoor. M, Fundamentals of Smart Materials, Publisher: Royal Society of Chemistry, 1st Edition, 2020.
4. Berg H, Bernhardsson S, and Johansson P, Electric Vehicle Batteries: Moving from Research towards Innovation, Publisher: Springer, 1st Edition, 2019.
5. Crouch S, Skoog D, Holler F, Principles of Instrumental Analysis, 2017.

L: 30; P: 30; TOTAL: 60 PERIODS

Course Code	ENGINEERING GRAPHICS	L	T	P	E	C
23ME11C	(Common to MECH, CIVIL, AIDS, EEE, IT)	**2**	**0**	**4**	**0**	**4**

COURSE OUTCOMES:

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

CO1: Construct the Engineering Curves and Perform Freehand Sketching.

CO2: Construct the Orthographic Projections of Points, Straight Lines and Lamina

CO3: Draw the Projections of Simple Solids in Different Positions.

CO4: Visualize the Sectional Views and Surface of Various Solids.

CO5: Draw the Isometric and Perspective Projections of Various Solids.

CO1: Construct the Engineering Curves and Perform Freehand Sketching. **L:6, P:12**

Principles of Engineering Graphics – significance. Usage of Drawing Instruments. Lettering and dimensioning exercise Construction of ellipse, parabola and hyperbola using eccentricity method– Construction of cycloids, Epi and Hypo-cycloids. Orthographic views of simple components by Free hand drawing - Transferring measurement from the given object to the free hand sketches.

CO2: Construct the Orthographic Projections of Points, Straight Lines and Lamina **L:6, P:12**

Principle of orthographic projections – Conventions - First angle and third angle projections. Projections of points placed in all quadrants – projections of straight lines – inclined to both reference planes - determination of true length and inclinations. Projections of regular polygonal surfaces and circular lamina inclined to both reference planes.

CO3: Draw the Projections of Simple Solids in Different Positions. **L:6, P:12**

Projections of simple solids like prisms, pyramids, cylinder and cone - axis inclined to one reference plane - change of position method.

CO4: Visualize the Sectional Views and Surface of Various Solids. **L:6, P:12**

Sectioning of simple solids – Axis perpendicular to horizontal plane- Drawing sectional views with true shape of the section. Development of lateral surfaces of truncated solids – Prisms, pyramids, cylinder and cone.

CO5: Draw the Isometric and Perspective Projections of Various Solids. **L:6, P:12**

Principles of isometric projection – Isometric scale – Isometric projections of simple solids like prism, pyramid, cone and cylinder – Combination of solids. Perspective projections of simple solids by visual-ray method

TEXT BOOKS:

1. Bhatt N.D, "Engineering Drawing", 54th Edition, Charotar Publishing House, 2023.
2. Shah M.B and Rana B.C, "Engineering Drawing", Pearson Education, 2nd Edition, 2009.

REFERENCES:

1. Natrajan K.V., "A text book of Engineering Graphics", Dhanalakshmi Publishers, Chennai, 2009.
2. Agrawal B. & Agrawal C.M., "Engineering Graphics", TMH Publication, 2nd Edition, 2013
3. Narayana K.L. & Kannaiah P, "Text book on Engineering Drawing", Scitech Publishers, 2011.
4. Gopalakrishna K.R, "Engineering Drawing", Subhas Publications, 32nd Edition, 2017.

L: 30; P: 60; TOTAL: 90 PERIODS

Course Code	ENGINEERING PRACTICE LABORATORY	L	T	P	E	C
23EE14C		0	0	4	0	2

PART A - MECHANICAL LABORATORY

COURSE OUTCOMES

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

CO1: prepare a different carpentry joints.

CO2: make a simple component using sheet metal operations.

CO3: make a joints using shield metal arc welding process.
CO4: perform lathe and shaping operations.

LIST OF EXPERIMENTS

1. **CARPENTRY PRACTICES**
   a. Study of carpentry tools
   b. Making T-Joints & Dove tail joints

2. **SHEET METAL PRACTICES**
   a. Study of sheet metal operations
   b. Making of a square tray and conical funnel

3. **METAL JOINING PROCESS PRACTICES**
   a. Study of Shield Metal Arc Welding (SMAW) process
   b. Welding of Butt joints and Lap joints using Shield Metal Arc Welding Process

4. **MACHINING PRACTICES**
   a. Study of lathe machine and shaper machine
   b. Perform lathe and shaping operations

P: 30; TOTAL: 30 PERIODS

TEXT BOOK:

1. Bawa H.S, "Workshop Practice", Tata McGraw Hill Publishing Company Limited, 2007

REFERENCES:

1. Ramesh Babu V, "Engineering Practices Laboratory Manual", Revised Edition, VRB Publishers Private Limited, Chennai, 2014.
2. Jeyachandran K, Natarajan S. and Balasubramanian S, "A Primer on Engineering Practices Laboratory", Anuradha Publications, 2007.
3. Jeyapoovan T, Saravanapandian M. and Pranitha S, "Engineering Practices Lab Manual", Vikas Publishing House Private Limited, 2006.
4. Rajendra Prasad A and Sarma PMMS, "Workshop Practice", Sree Sai Publication, 2002
5. Kannaiah P and Narayana K L, "Manual on Workshop Practice", Scitech Publications, 1999.

PART B
ELECTRICAL AND ELECTRONICS ENGINEERING PRACTICES LABORATORY

COURSE OUTCOMES

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

CO1: demonstrate simple residential wiring circuits
CO2: identify faults in any electrical appliances
CO3: measure energy and resistance to earth of electrical equipment
CO4: demonstrate basic electronic components based on their physical parameters and dimensions
CO5: Measure AC signal parameters using CRO and describe the fundamentals and characteristics of electronic components

LIST OF EXPERIMENTS

ELECTRICAL EXPERIMENTS

1. Residential House Wiring using Switches, MCB
2. Stair Case Wiring Connections
3. Study of wiring in different Lamps, Fan and Iron Box
4. Selection of protective devices
5. Coil Rewinding for Transformer and Fan using Rewinding Machine.
6. Measurement of Energy using Energy Meter for Single Phase System
7. Measurement of Earth Resistance using Electrical Equipment
8. Electrical fault detector.

ELECTRONICS EXPERIMENTS

9. Study and testing of Resistor, capacitor and inductor
10. Measurement of AC signal parameter (Peak-Peak, RMS, Period and Frequency) using CRO and DSO.
11. Study and Operation of Digital Multimeter, Function/Signal Generator and Regulated Power Supply
12. Verification of truth table for logic gates.
13. Characteristics of Diode, Transistor.
14. Soldering Practice

P: 30; TOTAL: 30 PERIODS

REFERENCES:

1. Jeyachandran K, Natarajan S and Balasubramanian S, "A Primer on Engineering Practices Laboratory", Anuradha Publications, 2007.
2. Electrical wiring, estimating and costing", Uppal, S.L. and Laroia, J.M. (1997), 5th Edition. Delhi: Khanna Publishers in Engineering.
3. Jeyapoovan T, Saravanapandian M and Pranitha S, "Engineering Practices Lab Manual", Vikas Publishing House Pvt. Ltd, 2006.
4. Bawa H.S., "Workshop Practice", Tata McGraw – Hill Publishing Company Limited, 2007.
5. Rajendra Prasad A and Sarma P.M.M.S., "Workshop Practice", Sree Sai Publication, 2002.
6. Kannaiah P and Narayana K.L., "Manual on Workshop Practice", Scitech Publications, 1999.

RECOMMENDED ONLINE COURSE(s)

https://nptel.ac.in/courses/108105053
https://onlinecourses.nptel.ac.in/noc22_ee109/preview

Course Code	தமிழரும் தொழில்நுட்பமும் (TAMILS AND TECHNOLOGY)	L	T	P	E	C
23SH21C	(Common to all B.E. / B.Tech. Degree Programmes)	1	0	0	0	1

COURSE OUTCOMES

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

CO1: தமிழர்களின் நெசவு மற்றும் பானைத் தொழில் நுட்பம், வடிவமைப்பு மற்றும் கட்டிடத் தொழில் நுட்பம், உற்பத்தித் தொழில்நுட்பம் பற்றிய அறிவு மற்றும் விளக்கும் திறன்.

CO2: தமிழர்களின் வேளாண்மை மற்றும் நீர்ப்பாசனத் தொழில்நுட்பம், அறிவியல் தமிழ் மற்றும் கணினித் தொழில்நுட்பம் பற்றிய அறிவு மற்றும் விளக்கும் திறன்.

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

CO1: Know and explain about Tamils weaving and Pottery technology, Design and construction Technology and Manufacturing Technology.

CO2: Know and explain about Tamils Agriculture and irrigation technology, Scientific Tamil and Tamil computing

CO1:தமிழர்களின் நெசவு மற்றும் பானைத் தொழில் நுட்பம், வடிவமைப்பு மற்றும் கட்டிடத் தொழில் நுட்பம் மற்றும் உற்பத்தித் தொழில் நுட்பம் பற்றிய அறிவு மற்றும் விளக்கும் திறன் L:9

சங்ககாலத்தில் நெசவுத் தொழில் - பானைத் தொழில்நுட்பம் - கருப்பு சிகப்பு பாண்டங்கள் - பாண்டங்களில் கீறல் குறியீடுகள்- சங்க காலத்தில் வடிவமைப்பு மற்றும் கட்டுமானங்கள் & சங்ககாலத்தில் வீட்டுப்பொருட்களில் வடிவமைப்பு - சங்ககாலத்தில் கட்டுமான பொருட்களும் நடுகல்லும் - சிலப்பதிகாரத்தில் மேடை அமைப்பு பற்றிய விவரங்கள் - மாமல்லபுரச் சிற்பங்களும் கோவில்களும் - மாதிரி கட்டமைப்புகள் பற்றி அறிதல், மீனாட்சி அம்மன் ஆலயம் மற்றும் திருமலை நாயக்கர் மஹால் - செட்டிநாடு வீடுகள் - பிரிட்டிஷ் காலத்தில் சென்னையில் இந்தோ-சாரோசெனிக் கட்டிடக்கலை- கப்பல் கட்டும் கலை - உலோகவியல் - இரும்புத்தொழிற்சாலை - இரும்பை உருக்குதல், எஃகு - வரலாற்றுச் சான்றுகளாக செம்பு மற்றும் தங்கநாணயங்கள் - நாணயங்கள் அச்சடித்தல் - மணி உருவாக்கும் தொழிற்சாலைகள் - கல்மணிகள், கண்ணாடி மணிகள் - சுடுமண் மணிகள் - சங்குமணிகள் - எலும்புத்துண்டுகள் - தொல்லியல்சான்றுகள் - சிலப்பதிகாரத்தில் மணிகளின் வகைகள்.

CO1:KNOW AND EXPLAIN ABOUT WEAVING AND CERAMIC TECHNOLOGY, DESIGN AND CONSTRUCTION TECHNOLOGY, MANUFACTURING TECHNOLOGY

Weaving Industry during Sangam Age – Ceramic technology – Black and Red Ware Potteries (BRW)– Graffiti on Potteries- Designing and Structural construction House & Designs in household materials during Sangam Age - Building materials and Hero stones of Sangam age — Details of Stage Constructions in Silappathikaram- Sculptures and Temples of Mamallapuram- Great Temples of Cholas and other worship places - Temples of Nayaka Period - Type study (Madurai Meenakshi Temple)- Thirumalai Nayakar Mahal - Chetti Nadu Houses, Indo –Saracenic architecture at Madras during British Period- Art of Ship Building - Metallurgical studies - Iron industry - Iron smelting, steel -Copper and gold Coins as source of history - Minting of Coins — Beads making-industries Stone beads -Glass beads - Terracotta beads -Shell beads/ bone beats - Archeological evidences – Gemstone types described in Silappathikaram.

CO2: தமிழர்களின் வேளாண்மை, நீர்ப்பாசனத் தொழில்நுட்பம், அறிவியல் தமிழ் மற்றும் கணினித் தமிழ் பற்றிய அறிவு மற்றும் விளக்கும் திறன். **L:6**

அணை, ஏரி, குளங்கள், மதகு - சோழர்காலக்குமுழித்தூம் பின் முக்கியத்துவம் -கால்நடை பராமரிப்பு - கால்நடைகளுக்காக வடிவமைக்கப்பட்ட கிணறுகள் - வேளாண்மை மற்றும் வேளாண்மைச் சார்ந்த செயல்பாடுகள் - கடல்சார் அறிவு - மீன்வளம் - முத்து மற்றும் முத்துக்குளித்தல் - பெருங்கடல் குறித்த பண்டைய அறிவு - அறிவுசார் சமூகம்- அறிவியல் தமிழின் வளர்ச்சி - கணினித் தமிழ் வளர்ச்சி - தமிழ் நூல்களை மின்பதிப்பு செய்தல் - தமிழ் மென்பொருட்கள் உருவாக்கம் - தமிழ் இணையக்கல்விக்கழகம் - தமிழ் மின்நூலகம் - இணையத்தில் தமிழ்அகராதிகள் - சொற்குவைத் திட்டம்.

CO2: KNOW AND EXPLAIN ABOUT AGRICULTURE TECHNOLOGY, IRRIGATION TECHNOLOGY, SCIENTIFIC TAMIL & TAMIL COMPUTING

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

REFERENCES:

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 சங்க கால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)
4. பொருநை–ஆற்றங்கரை நாகரிகம் (தொல்லியல் துறைவெளியீடு)
5. Social Life of Tamils(Dr.K.K.Pillay)A joint publication of TNTB & ESC and RMRL
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 InstituteofTamilStudies.)
9. Keeladi-Sangam City Civilization on the banks of river Vaigai (Jointly Published by: Department of Archaeology &Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Published by: The Author)

L: 15; TOTAL: 15 PERIODS

23GN05C	**PROFESSIONAL ETHICS AND HUMAN VALUES**	**L**	**T**	**P**	**E**	**C**
	(Common to all B.E. / B.Tech. Degree Programmes)	**2**	**0**	**0**	**0**	**2**

COURSE OUTCOMES

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

CO1: Recognize and practice the core human values and theories related to ethical behavior.

CO2: Analyze the engineering ethical breach from past study.
CO3: Distinguish and apply safety, responsibility and rights in workplaces.

CO1: Recognize and practice the core human values and theories related to ethical behavior **L: 10**

Moral dilemmas and moral autonomy - Kohlberg's theory - Gilligan's theory - Consensus and controversy –Case studies: Vigil mechanism, Whistle blowing - Protected disclosures - Personal ethics, work ethics and human values - Governing Regulation.

CO2 : Analyze the engineering ethical breach from past study **L: 10**

Engineering as experimentation - engineers as responsible experimenters - codes of ethics - a balanced outlook on law - Case study: The challenger disaster

CO3 : Distinguish and apply safety, responsibility and rights in workplaces **L: 10**

Safety and risk - assessment of safety and risk - risk benefit analysis and reducing risk - Collegiality and loyalty - respect for authority – confidentiality; Collective bargaining, Conflicts of interest - Case study; Occupational crime - professional rights - employee rights - Intellectual Property Rights (IPR) - discrimination. Case studies: The Three mile island and Chernobyl disaster

TEXT BOOK

1. Mike W Martin and Roland Schinzinger, "Ethics in Engineering", McGraw Hill, New York, 5th Edition, 2022

REFERENCES

1. BehnamTaebi, "Ethics and Engineering: An Introduction", Cambridge University Press, 2021
2. Ajesh Faizal, Aswathy S U, Roy V I, "Professional Ethics in Engineering: an Industry Perspective", Noor Publishing, 2021
3. R.S.Naagarazan, "A Textbook on Professional Ethics and Human Values", New age International Pvt. Ltd; 3rd Edition, 2022
4. Dr. P. Elamurugan, "Professional Ethics in Engineering", Notion Press, 2021

L:30; TOTAL:30 PERIODS

Course Code	APTITUDE ESSENTIALS	L	T	P	E	C
23GN01C	(Common to all B.E. / B.Tech. Degree Programmes)	1	0	0	0	1

COURSE OUTCOMES:

Upon the completion of the course the students will be able to
CO1: Recall the fundamentals in quantitative techniques and solve Number series problems quickly
CO2: Develop problem solving skills on Numbers and enhance arithmetic ability
CO3: Infer appropriate comparison and distribution methods using ratio and to form equations
CO4: Improve quantitative skills and solve problems on percentages and profit loss
CO5: Calculate data interpretation and data sufficiency in quantitative aptitude

CO1: Recall the fundamentals in quantitative techniques and solve Number series problems quickly **L : 3**

Numeric series – Finding missing numbers – Odd number out series - Letter series – Symbol series - Alphanumeric series

CO2: Develop problem solving skills on Numbers and enhance arithmetic ability **L : 3**

Number Types - HCF & LCM – Square root- Cubic root - divisibility criteria- Unit digit calculation- Prime factors

CO3: Infer appropriate comparison and distribution methods using ratio and to form equations **L : 3**

Ratio & Proportion: Comparison of Ratios - Variations: Direct and indirect proportion Ages: Present Age, Past Age & Future calculation

CO4: Improve quantitative skills and solve problems on percentage and profit loss **L : 3**

Concept of Percentage – Percentage calculation - Calculation of Percentage on Population Results on Depreciation .Profit and Loss –Percentage of Profit and Loss – Discount

CO5: Calculate data interpretation and data sufficiency in quantitative aptitude **L : 3**

Data Interpretation – Pie Chart – Bar Chart – Table Chart .Data Sufficiency in Logical Reasoning : Numbers, Ratio, Ages, Percentage and Profit Loss

REFERENCES:

1. Dr.R.Aggarwal, " Quantitative Aptitude", S Chand Publishing, Revised Edition 2017
2. R.V.Praveen, "Quantitative Aptitude and Reasoning" , 3rd Edition , Eastern Economy Edition, PHI Learning 2016

Video Materials

Profit Loss

https://youtu.be/PpVO7I8dx6U

https://youtu.be/_cW7_BUDYcw

Number series

https://youtu.be/_4ZJFkFE2XU

https://youtu.be/83nJmniFmNk

Numbers

https://youtu.be/81pwuMJ8OIU

https://youtu.be/VT_N9cacgl4

Square root and Cube root

https://youtu.be/nJSqsaT0AgU

https://youtu.be/_HyhwS8P9KY

Problems on Ages

https://youtu.be/6PCTRVmu-ek

https://youtu.be/eAl3BvO_Ipw

Data Interpretation

https://youtu.be/s99rda8e0vc

Course Code	FOURIER SERIES & TRANSFORM, COMPLEX ANALYSIS AND CALCULUS	L	T	P	E	C
23EE21C		3	1	0	0	4

COURSE OUTCOMES

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

Theory Component

CO 1: perform Fourier series expansion of the functions.

CO 2: compute the Fourier transforms of various functions.
CO3: interpret analytic function in transformations.
CO4: evaluate complex integration over contour.
CO5: analyze the concepts related to vector field.

CO 1 : perform Fourier series expansion of the functions

Dirichlet's conditions–General Fourier series –Half range series–Complex form of Fourier series– Parseval's identity–Harmonic analysis- Identification of frequencies. **L:9,T:3**

CO2 : compute the Fourier transforms of various functions

Fourier Integral theorem (without proof)–Fourier transform pair–Fourier Sine and Cosine transforms–Properties–Transforms of simple functions–Convolution theorem –Parseval's theorem. **L:9,T:3**

CO3 : interpret analytic function in transformations

Analytic functions - Necessary and Sufficient conditions (excluding proofs) - Harmonic and orthogonal properties of analytic functions - Harmonic conjugate - Construction of analytic functions- fluid flow problems - Conformal mapping: w= z+c, cz, 1/z and bilinear transformation. **L:9,T:3**

CO 4 : evaluate complex integration over contour

Statement and applications of Cauchy's integral theorem and Cauchy's integral formula (excluding proof) – Taylor's and Laurent's expansions - Singular points - Residues - Cauchy's Residue theorem (excluding proof) - Application of residue theorem to evaluate real integrals - Unit circle and semi - circular contour (excluding poles on boundaries). **L:9,T:3**

CO5: analyze the concepts related to vector calculus

Differentiation of vectors : Gradient, Divergence, Curl and Directional derivatives – Line, Surface and Volume Integrals - Statement of Green's, Gauss divergence and Stokes' theorem - Simple applications involving rectangular parallelepiped and cubes. **L:9,T:3**

TEXT BOOKS:

1. Grewal.B.S, Higher Engineering Mathematics, 44th Edition, Khanna Publications, Delhi, 2021.
2. Erwin Kreyszig, Advanced Engineering Mathematics, 10th Edition, Wiley India, 2017.

REFERENCES:

1. Bali.N.P. and Manish Goyal, A Textbook of Engineering Mathematics, 9th Edition, Laxmi Publications Private Limited., 2018.
2. Ramana B.V, Higher Engineering Mathematics, Tata Mc-Graw Hill Education, New Delhi, 2017.
3. Jain.R.K. and Iyengar.S.R.K., Advanced Engineering Mathematics, 5th Edition, Narosa Publishing House Private Limited, 2016.
4. Michael D .Greenberg, Advanced Engineering Mathematics, 2nd Edition, Pearson Education, 2021.

L: 45; T: 15; TOTAL: 60 PERIODS

23EC22C /	**MATERIALS SCIENCE**	**L**	**T**	**P**	**E**	**C**
23EE22C	(Common to ECE & EEE Branches)	**2**	**0**	**0**	**0**	**2**

COURSE OUTCOMES:

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

Theory Components:

CO1: explain the conductivity in metals using free electron theory.
CO2: describe the fundamental properties ofsemiconductors.
CO3: apply the magnetic and dielectric properties for relevant electrical and electronics engineering applications.
CO4: illustrate the optical properties and their applications to optical devices.
CO5: apply the concepts of nanomaterials for nano devices.

CO1: explain the conductivity in metals using free electron theory.

Conduction in metals - Classical free electron theory of metals – Mobility and electrical conductivity - Thermal conductivity of metals - Wiedemann – Franz law – Quantum free electron theory – merits and limitations of free electron theory (FET) - Fermi-Dirac Statistics - Density of States. **L:6**

CO2: describe the fundamental properties of semiconductors.

Energy band diagram - Direct and indirect band gap - Carrier concentration and Fermi level in anintrinsic semiconductor- Carrier concentration and Fermi level in N-type and P-type semiconductors - Carrier transport in Semiconductors: Drift, mobility, diffusion and carrier lifetime - Hall effect **L:6**

CO3: apply the magnetic and dielectric properties for relevant electrical and electronics engineering applications.

Magnetic materials – Classification – Hysteresis – Ferrites - $BaTiO_3$ – Application of Nd-Fe-B magnets. Electric polarization – Different types of polarization – Temperature and frequency dependence – Dielectric loss and dielectric breakdown – dielectric materials applications - capacitors and transformers. **L:6**

CO4: illustrate the optical properties and their applications to optical devices.

Light waves in a homogeneous medium – Refractive index – Dispersion – Classification of Optical materials – Luminescence - Fluorescence– Phosphors – Photoconductivity – Display devices - Principle and working of LED, OLED, LCD - Laser diode – Photodiode (CdS and CdSe)- Optical Amplifiers. **L:6**

CO5: apply the concepts of nanomaterials for nano devices.

Nanomaterials - synthesis - properties - Band gap of nanomaterials – Quantum Tunneling – Quantum cascade lasers -Nano magnets - GMR - Conductivity of metallic nanowires – Carbonnanotubes: Properties and applications - QLED – Spintronics and its device application. **L:6**

TEXTBOOKS:

1. Dr. M. Arumugam, Materials Science, Anuradha Publications, 2018
2. S. M. Sze and M. K. Lee, Semiconductor Physics and Devices, Wiley, 2021.
3. T. Pradeep, Nano: The Essentials: Understanding Nanoscience and Nanotechnology, McGraw-Hill Education, 2017.

4. Hilmi Unlu and Norman J. M. Horing, Progress in Nanoscale and Low-Dimensional Materials and Devices, Springer Link, 2022.

REFERENCES:

1. S.O Pillai, Solid State Physics, 10th edition, NEW AGE International Publishers, 2022
2. W.D.Callitser and D.G. Rethwish. Materials Science and Engineering, John Wiley & Sons, 2014.
3. Juan Martinez-Vega, Dielectric Materials for Electrical Engineering, Wiley, 2013
4. G.W. Hanson, Fundamentals of Nanoelectronics, Pearson Education, 2009.
5. J. Wilson and J.F.B. Hawkes, Optoelectronics, Pearson Education, 2018.

L : 30; TOTAL : 30 PERIODS

Course Code 23EE23C	**BASIC CIVIL AND MECHANICAL ENGINEERING**	**L**	**T**	**P**	**E**	**C**
		3	**0**	**0**	**0**	**3**

COURSE OUTCOMES

Upon the completion of this course, the students will be able to
CO1: discuss the materials and measurement techniques used in civil engineering.
CO2: describe the fundamental elements of civil engineering structures.
CO3: explain the basic manufacturing processes
CO4: demonstrate the components and working principle of IC engines and power plants
CO5: describe the working principle of refrigeration and air conditioning system

CO1: discuss the materials and measurement techniques used in civil engineering **L:9**

Surveying: Objects – classification – principles – measurements of distances – angles – leveling – determination of areas – Contours. Civil Engineering Materials: Bricks – stones – sand – cement – concrete – steel - timber – modern materials, Thermal and acoustic insulating materials, Decorative panels, water proofing materials, Modern uses of Gypsum, Prefabricated Building component (brief discussion only).

CO2: describe the fundamental elements of civil engineering structure **L:9**

Building Plans – Setting out of a building – Foundations – Types of foundations - Bearing capacity and settlement - Brick masonry – stonemasonry – beams – columns – lintels – roofing – flooring – plastering –- Types of Bridges and Dams - water supply network - Rain water harvesting – Solid waste management- Introduction to Highways and Railways – Introduction to Green Buildings.

CO3: explain the basic manufacturing processes **L:9**

Overview of manufacturing processes - Introduction to metal casting process – Welding Processes- Bulk deformation processes - Powder metallurgy and plastic processing.

CO4: demonstrate the components and working principle of IC engines and power plants **L:9**

Internal combustion engines-Classification – Construction - Working principle- Four stroke and two stroke cycles - Comparison of four stroke and two stroke engines. Power Plants – Classification – Construction and working principle - steam, Gas,

Diesel, Hydroelectric, Nuclear, Wind Energy and Solar Power plants.

CO5: describe the working principle of refrigeration and air conditioning system **L:9**

Terminology of Refrigeration and Air Conditioning. Principle of vapour compression -Window and Split type room Air conditioner.

TEXT BOOKS:

1. Shanmugam G and Palanichamy M.S, "Basic Civil and Mechanical Engineering", Tata McGraw Hill Publishing Co., New Delhi, 2016.
2. Shanmuga Sundaram S and Mylsamy K, "Basic Civil and Mechanical Engineering", Cengage Learning, 2011.
3. Ramamrutham S, 'Basic Civil Engineering', DhanpatRai Publishing Co.(P)Ltd, 2013
4. Venugopal K, Prabhu Raja V and SreeKanjana G "Basic Mechanical Engineering", Anuradha Publications., Chennai, 2014

REFERENCES:

1. Punmia, B.C, Ashok Kumar Jain, Arun Kumar Jain, 'Basic Civil Engineering', Lakshmi Publishers, 2012.
2. Seetharaman S., 'Basic Civil Engineering', Anuradha Agencies, 2005.
3. Rangwala, S.C, 'Building materials', Charotar Publishing House, Pvt. Limited, 27th Edition, 2009.
4. S.K. Garg, "Water Supply Engineering", Khanna publishers, Delhi, 2005
5. Khanna and Justo, "Highway Engineering", New Chand and Bros, Roorkee, 2000
6. Shantha Kumar S R J, "Basic Mechanical Engineering", Hi-tech Publications, 2013.
7. Kalpakjian.S, "Manufacturing Engineering and Technology", Pearson Education India Edition, 2013

L: 45; TOTAL: 45 PERIODS

Course Code	**ELECTRIC CIRCUIT ANALYSIS**	**L**	**T**	**P**	**E**	**C**
23EE24C		**3**	**1**	**2**	**0**	**5**

COURSE OUTCOMES

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

Theory Component

CO1: describe the basic concepts of circuit analysis and basic laws

CO2: apply the network theorems and reduction techniques to estimate the steady state response for a given excitation

CO3: examine the application of series, parallel resonance and coupled circuits

CO4: infer and Evaluate the transient response of electric circuit and characteristics of two port networks.

CO5: analyse three-phase balanced and unbalanced systems in star and delta configurations.

Practical Component

CO6: examine the electric circuits using mesh and nodal analysis

CO7: make use of network theorems to simplify the circuits.

CO8: compute the frequency response of resonant and tuned circuits
CO9: analyze the dynamic behavior of electric circuits using simulation tool.
CO10: infer the behaviors of balanced and unbalanced systems in star and delta configurations using simulation tool.

CO1: describe the basic concepts of circuit analysis and basic laws **L:9, T:3**
CO6: examine the electric circuits using mesh and nodal analysis **P:6**

Resistive, Inductive and Capacitive elements - Power, Power Factor and Energy - Ohm's Law– Kirchoffs laws and its verification – voltage and current division - source transformation – star delta conversion- Mesh current and node voltage analysis in D.C and A.C. circuits – Experimental verification of mesh and nodal analysis - Phasor diagram - Average and RMS value.

CO2: apply the network theorems and reduction techniques to estimate the steady state response for a given excitation **L:9, T:3**
CO7: make use of network theorems to simplify the circuits **P:6**

Thevenin and Norton Theorems and its Experimental verification – Superposition Theorem and its Experimental verification – Maximum power transfer theorem and its Experimental verification – Reciprocity Theorem and its Experimental verification – Millman's theorem.

CO3: examine the application of series, parallel resonance and coupled circuits **L:9, T:3**
CO8: compute the frequency response of resonant and tuned circuits **P:6**

Series, parallel resonance and its Experimental verification on Frequency response – Quality factor and Bandwidth – Self and mutual inductance – Coefficient of coupling – Single tuned circuits and experimental verification –Measurement of self inductance of a coil

CO4: infer and Evaluate the transient response of electric circuit and characteristics of two port networks. **L:9, T:3**
CO9: analyze the dynamic behavior of electric circuits using simulation tool. **P:6**

Review of Laplace transformation; Laplace transform of network and time domain solution for RL, RC and RLC networks for AC and DC excitations; Transient behaviour of circuit elements under switching conditions and their representations, evaluation of initial and final conditions in RL, RC and RLC circuits with AC and DC excitations- experimental verification of transient response of RL, RC circuits for DC input

CO5: analyse three-phase balanced and unbalanced systems in star and delta configurations **L:9, T:3**
CO10: infer the behaviors of balanced and unbalanced systems in star and delta configurations using simulation tool. **P:6**

Review of balanced system; Unbalanced systems: Delta-connected, three-wire star connected, four-wire star-connected loads; Analysis of unbalanced 3-wire star load: Kirchhoff's law, loop current method, star/delta conversion method using millman's theorem- Simulation of three phase balanced and unbalanced star, delta networks circuits using Simulation package.

TEXT BOOKS:

1. Charles K Alexander, Matthew Sadiku, Fundamentals of Electric Circuits, 2022, 7th Edition, McGraw Hill Education.
2. William H. HaytJr, Jack E. Kemmerly, and Steven M. Durbin, Engineering Circuits Analysis, McGraw Hill publishers, New Delhi, 2019.

REFERENCES:

1. John Bird, "Electrical Circuit Theory and Technology", 6th Edition, Newnes Publication, 2017.
2. Sudhakar A and Shyam Mohan SP, "Circuits and Network Analysis and Synthesis", McGraw. Hill Education, 5th Edition, New Delhi, 2015.
3. Joseph A. Edminister, Mahmood Nahri, "Electric circuits", Schaum's series, McGraw Hill, New Delhi, 2017.

L: 45; T:15; P: 30; TOTAL: 90 PERIODS

Course Code	PROFESSIONAL ENGLISH	L	T	P	E	C
23SH22C	(Common to all B.E. / B.Tech. Degree Programmes)	2	0	2	0	2

COURSE OUTCOMES

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

Theory Component

CO1: extend the primary language skills to develop critical thinking

CO2: build the secondary language skillsfor professional competence

Practical Component

CO3: apply the vital sub-functions of listening in particular context

CO4: take part in propagating ideas through effective oral communication

CO5: inferring information using various reading techniques

CO6: construct professional content via distinct methods of writing

Soft skill Component

CO7: develop interpersonal, communicational and behavioral attributes

CO1:extend the primary language skills to develop critical thinking

CO3: apply the vital sub-functions of listening in particular context

L:6,P:16

CO4: take part in propagating ideas through effective oral communication

If Conditionals – Standard Abbreviations –Types of Listening (Comprehensive, Informational, Critical Listening) – One Word Substitution, Components of Speaking

Listening for Specific Information –Listening to Speech (Oxford Union Society) – Listening to Science Talks or Theories

Product Description – Chart Description – Process Description – Group Discussion (Uses – Structure – Strategies – Team Work – Positive & Negative Body Languages – Samples – Demo)

CO2:build the secondary language skills for professional competence L:5,P:18

CO5: inferring information using various reading techniques

CO6: construct professional content via distinct methods of writing

Synonyms – Intensive and Extensive Reading –Error Spotting (Based on Concord, Pronoun, Articles & Adverb Placement)– Writing Style (Persuasive, Expository & Descriptive)

Newspaper Reading – Reading Comprehension (Fiction & NonFiction)

Business Letters for Quotations and Clarification, Placing Orders and Making Complaints – Proposal Writing – Job Application Letter & Resume Preparation – Paragraph Writing – Content Writing

TEXT BOOKS

1. Lucantoni, Peter & Lydia Kellas. "English as a Second Language Workbook", 6th Edition, Cambridge University Press, 2022.
2. Twain, Mark. "The Adventures of Tom Sawyer", 1st Edition, Pegasus, 2012.
3. Clear, James. "Atomic Habits", 1st Edition, Dreamliners, 2022.
4. Garcia, Hector & Francesc Miralles. Ikigai: The Japanese Secret to a long and Happy Life. 1st Edition, Tuttle Publishing, 2021.
5. Elbow, Peter, "Writing with Power" 2nd Edition, Oxford University Press, 1998.

REFERENCES

1. Butterfield, Jeff. "Soft Skills for Everyone". 2nd Edition, Cengage, 2020
2. Raman, Meenashi & Sangeetha Sharma. Professional English. 1st Edition, Oxford University Press, 2018

L: 11; P: 34; TOTAL: 45 PERIODS

Course Code	PROBLEM SOLVING TECHNIQUES	L	T	P	E	C
23CS11C	(Common to all B.E. / B.Tech. Degree Programmes)	3	0	2	0	4

COURSE OUTCOMES

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

Theroy Component

CO1:apply fundamentals of problem solving techniques to develop simple algorithms for arithmetic and logical problems

CO2:apply fundamental, sequential, conditional logic statements and arrays for solving basic problems

CO3: implement modular programming concept using user defined functions

CO4: inscribe programs using pointers and to allocate memory for user defined data types using dynamic memory management functions

CO5: develop file processing application programs

Practical Component

CO6: develop programs for simple algorithms using sequential and Control structures

CO7: inscribe programs using arrays, functions and pointers to work with multiple data items.

CO8: develop application programs using structures and files concept.

CO1: apply fundamentals of problem solving techniques to develop simple algorithms for arithmetic and logical problems **L:6**

Overview of programming: Problem Solving in Everyday Life, Types of Problem, Computer-based problem solving, Algorithms - Building blocks of algorithms (statements, control flow, functions) - Notation (pseudo code, flow chart) – Problem solving aspect – Top down design – Implementation of algorithms – Program Verification – Efficiency of algorithms – Analysis of algorithm.

CO2: apply fundamental, sequential, conditional logic statements and arrays for solving basic problems **L:12, P:10**

Data Types - Constants – Variables - Keywords – Operators– Problem Solving using fundamental algorithms. Control Statements: Branching and Looping - Algorithms Using Selection and Repetition - Summation of a set of numbers, Reversing Digits of an Integer - Implementation of fundamental algorithms and factoring methods - Array Techniques - Array order reversal, Array Counting, Finding maximum and the minimum value in a set

CO6: develop programs for simple algorithms using sequential and Control structures

Solve problems using control statements (Decision making and Looping)

CO7: inscribe programs using arrays, functions and pointers to work with multiple data items.

Problem solving based on Array Handling(1D and 2D, Multi-dimensional arrays, traversal, rotation) - Solve problems to handle strings

CO3: implement modular programming concept using user defined functions **L:10, P:8**

Modular Programming approach: Modularization and recursion - Bubble Sort, Selection Sort, Linear Search, Binary Search, Implementation of sorting and searching

CO7: inscribe programs using arrays, functions and pointers to work with multiple data items.

Solve problems by using modular approach (Functions and Recursion)

CO4: inscribe programs using pointers and to allocate memory for user defined data types using dynamic memory management functions **L:12, P:10**

Pointer Concept – add numbers using call by reference – finding maximum number from list of numbers - permutations of a given string using pointers – Implementation of function returns a pointer;

Structures & Union - finding the largest element of an array using Dynamic Memory Allocation – Implementation of Student database in structure using Dynamic Memory Allocation;

CO7: inscribe programs using arrays, functions and pointers to work with multiple data items.

Build efficient solutions to manage memory efficiently through Pointers.

CO8: develop application programs using structures and files concept.

Develop applications using Structures

CO5: Develop file processing application programs **L:5, P:2**

File Handling: Files - Introduction, Types of file processing: Sequential access, Random access – Implementation of word count, copy file, Voter's age validation, Marks range validation

CO8: Develop application programs using structures and files concept.

Develop appliactions using Files

TEXT BOOKS:

1. Maureen Sprankle and Jim Hubbard, Problem Solving and Programming Concepts, Prentice Hall, 9th Edition, 2012.
2. R.G Dromey, How to solve it by Compute, Pearson education, Delhi, 2nd Edition, 2021.

REFERENCES:

1. Behrouz A. Forouzan, Richard F.Gilberg, P.Golda Jeyasheeli, G.Priyanka, S.T.Veena , Problem solving Using C A Structured Programming Approach, Volume I & II, 1st Edition, Cengage Publication, 2022
2. Karl Beecher, Computational Thinking: A Beginner's Guide to Problem Solving and Programming, BCS Learning & Development Limited, 1st Edition, 2017.
3. Byron S. Gottfried, Jitendar Kumar Chhabra, Programming with C, Tata McGraw Hill Publishing Company, New Delhi, 4th Edition, 2018.
4. Kernighan B.W., Ritchie D.M., C Programming Language (ANSI C), Prentice Hall of India Private Limited., New Delhi, 2nd Edition, 2010.
5. Pradip Dey and Manas Ghosh, Programming in C, Oxford University Press, New Delhi, 2018.
6. Yashavant P. Kanetkar, Let Us C, BPB Publications,16th Edition, 2020
7. H. M.Deitel, P. J. Deitel, C How to Program, Pearson Education., New Delhi, 7th Edition, 2016.

L: 45; P: 30; TOTAL: 75 PERIODS

Course Code	INNOVATION THROUGH DESIGN THINKING	L	T	P	E	C
23GN02C	(Common to all B.E. / B.Tech. Degree Programmes)	0	0	0	4	2

COURSE OUTCOMES

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

Experiential Component

CO1: Analyse the impact of design thinking process.

CO2: Practice design thinking process through real world problems.

Soft skill Component

CO3: Present survey conclusions on selected real-world problems.

CO1: Analyse the impact of design thinking process **30**

Design thinking process: history and phases -Ideation tools: brainstorming, mind mapping, scrambler method, six thinking hats -case studies.

CO2: Practice design thinking process through real world problems **30**

Real world problem selection-Practicing the preliminary stages of design thinking process - work presentation.

TEXT BOOKS:

1. Falk Uebernickel, Li Jiang, Walter Brenner, Britta Pukall, Therese Naef, "Design Thinking: The Handbook", WS Professional, 2020
2. PavanSoni, "Design Your Thinking: The Mindsets, Toolsets and Skill Sets for Creative Problem solving", Penguin Random House, 2020

REFERENCES:

8. Michael Lewrick, "The Design Thinking Playbook", Wiley, 2019
9. Kathryn Christopher, "Design Thinking in Engineering", Kendall Hunt Publishing Company, 2019
10. Robert Curedale, "Design Thinking Process & Methods" Design Community College Inc, 5th Edition, 2019
11. David Lee, "Design Thinking in the Classroom", Ulysses Press, 2018
12. Jimmy Jain, "Design Thinking for Startups", Notion Press, 2018
13. Monika Hestad Silvia Rigoni Anders Grnli, "The Little Booklet on Design Thinking: An Introduction", Zaccheus Entertainment, 2nd Edition, 2017
14. Scott Swan, Michael G.Luchs and Abbie Griffin, "Design Thinking: New Product Development Essentials", Wiley-Blackwell, 2016
15. D.M. Arvind Mallik, "Design Thinking for Educators", Notion Press, 2019

E:60; TOTAL:60 PERIODS

Course Code	ELECTROMAGNETIC THEORY	L	T	P	E	C
23EE31C		3	1	0	0	4

COURSE OUTCOMES

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

Theory Component

CO1: apply vector calculus on electromagnetic fields in different coordinate system
CO2: analyze the electrostatic field distribution in different medium along with their applications
CO3: evaluate the magneto static field distribution in different medium along with their applications
CO4: illustrate different methods of emf generation and Maxwell's equations
CO5:examine the concept of electromagnetic waves in different spaces and characterizing parameters

CO1: Apply vector calculus on electromagnetic fields in different coordinate system **L:9, T:3**

Sources and effects of electromagnetic fields- review of scalar and vector fields- Coordinate systems (rectangular, cylindrical and spherical) – coordinate transformation- Vector calculus- vector operator del, gradient, divergence and curl- integral theorems of vectors.

CO2: Analyze the electrostatic field distribution in different medium along with their applications **L:9, T:3**

Coulomb's law, Electric field intensity- point charges, Line, Surface and Volume charge distributions - Gauss law and its applications - Electric field in free space, conductors, dielectrics -Electric potential - different configurations- potential due to electric dipole - Electrostatic Energy and Energy density–Electric Boundary conditions - Capacitance - Electric field in multiple dielectrics and configuration - Laplace, Poisson's equations and solutions

CO3: Evaluate the magnetostatic field distribution in different medium along with their applications **L:9, T:3**

Lorentz force – Biot-Savart's Law – Ampere's Law - magnetic fields by differential current element – Magnetic force due to current carrying conductors - Magnetic flux and magnetic flux density – different configuration - Scalar and Vector Magnetic potentials -- Magnetostatic Energy and Energy density – Magnetic circuits - Magnetization and permeability - Magnetic boundary conditions – Torque - Inductance calculations.

CO4: Explain different methods of emf generation and Maxwell's equations **L:9, T:3**

Faraday's law for Electromagnetic induction - Transformer and motional EMF – Faraday Disc generator - Displacement current - Maxwell's equation (differential & Integral form) - Relation between field theory and circuit theory

CO5: examine the concept of electromagnetic waves in different spaces and characterizing parameters **L:9, T:3**

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

TEXT BOOKS:

1. Sadiku Matthew N.O., "Principles of Electromagnetics", 6th Edition, Oxford University Press, New Delhi, 2021.
2. A. Pramanik, "Electromagnetism - Theory and applications", PHI Learning Pvt. Ltd, New Delhi, 2009.

REFERENCES:

1. Hayt W.H., Buck J.A and JaleelAkhtar M., "Engineering Electromagnetics" 9th Edition McGraw Hill Education, India, 2020.
2. Henry W.Ott, "Electromagnetic Compatibility Engineering", Wiley-Blackwell; Revised Edition (11 September 2009).
3. J. Edminister and Vishnu Priye, "Electromagnetics", 2nd Edition, Schaum's Series, 2017.
4. A. Pramanik, "Electromagnetism-Problems with solution", Prentice Hall India, 2012.

L: 45; T: 15; TOTAL: 60 PERIODS

Course Code	TRANSFORMS, PROBABILITY AND STATISTICS	L	T	P	E	C
23EE32C		3	1	0	0	4

COURSE OUTCOMES

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

Theory Component

CO 1: apply Laplace transform to solve ordinary differential equations.

CO 2: solve difference equations using Z-Transform.

CO3: perform basic probability concepts and standard distributions.

CO4: find the correlation and regression of two dimensional random variables.

CO5: calculate the various measures of central tendencies.

CO 1 : apply Laplace transform to solve ordinary differential equations

Definition of Laplace transform and its inverse – Transforms of elementary functions – Properties – Transforms of periodic functions – Initial and final value theorems – Convolution theorem.- solutions of linear ordinary differential equations with constant coefficients - Solutions of simultaneous differential equations of first order with constant coefficients - *Determine the solution of ordinary differential equations in Laplace transform – Activity through software.* **L:9,T:3**

CO2 : solve difference equations using Z-Transform

Z– transform –Elementary properties – Inverse Z–transform – Convolution theorem- Initial and final value theorem – Formation of difference equations –Solutions of difference equations using Z–transform **L:9,T:3**

CO3 : perform basic probability concepts and standard distributions

Discrete and continuous random variables - Moments - Moment generating functions and their properties. Binomial, Poisson, Geometric, Uniform, Exponential, Gamma, and Normal distributions.. **L:9,T:3**

CO 4 : find the correlation and regression of two dimensional random variables

Joint distributions - Marginal and conditional distributions – Covariance - Correlation and regression - Transformation of random variables – Central Limit Theorem. **L:9,T:3**

CO5: calculate the various measures of dispersion

Central tendencies -Mean, median, mode - Measures of Dispersion –Mean deviation, and Quartile deviation–Moments– Skewness –Kurtosis - Correlation and Regression - *Carry out performance study on measures of central tendencies – Case Study through software***.** **L:9,T:3**

TEXT BOOKS:

1. Grewal.B.S. Higher Engineering Mathematics, 44th Edition, Khanna Publications, Delhi, 2021.
2. Richard A. Johnson, Irwin Miller, John Freund, Miller & Freund's, Probability and Statistics for Engineers, 9th Edition, Pearson Education Limited, Global Edition, 2017.
3. Erwin Kreyszig, Advanced Engineering Mathematics, 10th Edition, Wiley India, 2017

REFERENCES:

1. Ramana B.V, Higher Engineering Mathematics, Tata Mc-Graw Hill Education, New Delhi, 2017.
2. Jain.R.K. and Iyengar.S.R.K., Advanced Engineering Mathematics, 5th Edition, Narosa Publishing House Private Limited, 2016.
3. R.E. Walpole, R.H. Myers, S.L. Myers, and K Ye, Probability and Statistics for Engineers and Scientists, Pearson Education, Asia, 9th Edition, 2016

L: 45; T:15; TOTAL: 60 PERIODS

Course Code	DC MACHINES AND TRANSFORMERS	L	T	P	E	C
23EE33C		3	0	2	0	4

COURSE OUTCOMES

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

Theory Component

CO1: illustrate the fundamentals of magnetic circuits and electromechanical energy conversion.

CO2: recognize the different types of transformer and evaluate the performance of transformer.

CO3: identify the DC generator for suitable applications and familiarize the performance of DC generator

CO4: select and draft specifications of DC motors for various applications along with speed control methods.

CO5: analyze the performance parameters/characteristics of the DC machines & transformer under various operating conditions through proper testing

Practical Component

CO6: estimate the magnetic losses in magnetic circuits

CO7: investigate the performance characteristics, efficiency, regulation & significance of various transformer connection

CO8: demonstrate the DC Generator Characteristics for various loading parameters

CO9: demonstrate the DC Motor Characteristics for various loading parameters

CO10: explore the performance of DC Machines and Transformers testing

CO1: describe the fundamentals of Magnetic Circuits and Electromechanical Energy Conversion **L:9, P:6**

CO6: estimate the magnetic losses in magnetic circuits

Magnetic Circuits : MMF, Reluctance & Permeability - Magnetic Materials - B-H Curve, Magnetic Losses - Experimental Verification of Separation of magnetic losses in magnetic circuit – Faraday's law – Energy Stored in the magnetic field – Electromechanical Energy Conversion – Singly Excited System – Multiple Excited System – Rotating Magnetic Field

CO2: Recognize the different types of transformer and evaluate the performance of transformer **L:9, P:6**

CO7: investigate the performance characteristics, efficiency, regulation and significance of various transformer connections.

Construction and Working Principle –EMF Equation- Equivalent circuit Parameters – Phasor Diagram – Auto transformer -Three Phase transformer- Experimental Verification of Load Test on Single and three Phase transformer - Study of Three Phase transformer Connections – Transformer materials, Applications of transformers, Special purpose Instrument transformers (CT and PT), Emerging technologies - Earthing Transformer, Pulse Transformer, High frequency Transformer Solid-State Transformer, Dry-type transformers, Smart transformer, Green transformer

CO3: identify the DC Generator for suitable applications and familiarize the performance of DC Generator **L:9, P:6**

CO8: demonstrate the DC Machines Characteristics for various loading parameters

Construction - Principle of Operation – Lap and Wave windings – EMF Equation – Armature Reaction – Method of Excitation – Commutation – Interpoles and Compensating Winding – Characteristics of DC Generator – Experimental Verification of Open Circuit and Load Characteristics of DC Shunt Generator- Load Characteristics of DC series Generator- Load Characteristics of DC Cumulative and Differential Compound Generator Applications (Qualitative Case Study).

CO4: select and draft specifications of DC motors for various applications along with speed control methods. **L:9, P:6**

CO9: demonstrate the DC Motor Characteristics for various loading parameters

Principle of Operation – Back EMF – Torque Equation – Types of Motors – Experimental verification of Load test on DC Shunt Motor, DC Series Motor- Load Test on Cumulative and Differential DC Compound Motor- Speed Control of DC Shunt Motor - Starters and Speed Control – Speed Torque Characteristics – Braking— selection of motor - Applications (Qualitative Case Study).

CO5: Analyze the performance parameters/characteristics of the DC machines & Transformer under various operating conditions through proper testing **L:9, P:6**

CO10: explore the performance of DC Machines and Transformers testing

DC Machines: Losses & Efficiency – Condition for Maximum Efficiency - Retardation test – Swinburne's Test – Hopkinson's Test, Transformer: Losses & Efficiency, Condition for Maximum Efficiency –Experimental verification of Swinburne's Test- Hopkinson's test- Sumpner's test- Open circuit and Short Circuit Test on Single Phase Transformer All day efficiency and Voltage Regulation – OC & SC Test - Sumpner's test – Polarity Test.

TEXT BOOKS:

1. Nagrath I. J and Kothari D. P. "Electric Machines", 5th Edition, Tata Mc Graw Hill Publishing Company Limited, 2017.
2. S.K.Bhattacharya "Electrical Machines", 4th Edition, McGraw Hill Education, 2017.

REFERENCES:

1. M.N.Bandyopadhyay, Electrical Machines Theory and Practice, PHI Learning Private Limited, New Delhi, 2011.
2. Fitzgerald. A.E., Charles Kingsely Jr, Stephen D.Umans, "Electric Machinery", 7th Edition, Tata Mc-Graw Hill Books Company, 2013.
3. P.S. Bimbhra, "Electrical Machinery", Khanna Publishes, 7th Edition, 2011.
4. B.L.Theraja, and A.K.Theraja, A text book of Electrical Technology, Shree Hari Publications, 2021.
5. V.K.Metha and Rohit Metha "Principles of Electrical Machines" S.Chand Publications, 2014.
6. "Transformers", 2nd Edition, BHEL, 2003.
7. IEC60076 -Transformer standards, IEC 60034 rotating machines.

L: 45; P: 30; TOTAL: 75 PERIODS

Course Code	MEASUREMENT AND INSTRUMENTATION	L	T	P	E	C
23EE34C		3	0	2	0	4

COURSE OUTCOMES

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

Theory Component

CO1: analyze the performance characteristics of instruments

CO2: describe the construction and operation of various measuring instruments.

CO3: select appropriate AC and DC bridges for the measurement of electrical parameters

CO4: illustrate the operation of transducer suitable for measurement of non electrical quantities
CO5: outline the significance of computer-based data acquisition and digital display devices.

Practical Component

CO6: perform statistical error analysis for instrument data to describe its characteristics.
CO7: calibrate the instruments with standards and design the components for extending its range.
CO8: design the DC and AC bridges for measuring electrical parameters
CO9: build signal conditioning circuit for transducer and analyze its transient and steady state behaviors.
CO10: utilize smart system for parameter measurement and monitoring using digital technology.

CO1: analyze the performance characteristics of instruments **L:8, P:2**
CO6: perform statistical error analysis for instrument data to describe its characteristics.

Methods of Measurement – Fundamental and derived units – Elements of instrument – Static and Dynamic characteristics of instruments – Error types– Propagation of error - Statistical error analysis – Performance measures –Experimental measurement and analysis of Error for a set of data from a batch of resistance – Standard and Calibration

CO2: describe the construction and operation of various measuring instruments. **L:9, P:8**
CO7: calibrate the instruments with standards and design the components for extending its range

Types of analog meters –Principle of Moving coil instruments –Moving iron instruments –Extension of meter range –Design and validate multipliers for extending the range of voltmeter and ammeter- Induction type wattmeter and energy meters – Calibration of three phase energy meter by two wattmeter method and validate using multifunction meter Instrument transformer -Calibrate fixed and variable ratio CT in current measurement- Optical CT-CVT-IVT.

CO3:select appropriate AC and DC bridges for the measurement of electrical parameters **L:10, P:10**
CO8: design the DC and AC bridges for measuring electrical parameters

Balance condition – Source & Detectors – Wheatstone bridge, Kelvin's double bridge – Experimental validation - Maxwell's bridge – Anderson bridge – Experimental design of Maxwell's bridge and Anderson bridge – De-Sauty bridge – Schering bridge – Experimental design of Schering bridge and De-Sauty bridge– Wein bridge – Megger– Earth resistance –Localization of cable fault – Experimental verification of Megger.

CO4: illustrate the operation of transducer suitable for measuring a physical parameter **L:9, P:6**
CO9: build signal conditioning circuit for transducer and analyze its transient and steady state behaviors.

Transducers selection criteria – Types of transducers – Potentiometer – Strain gauge– Encoders – LVDT – Pressure transducer – Calibration experiment for Resistive, inductive and capacitive transducers – Temperature transducers – Build signal conditioning circuit for thermocouple– Transient and steady state analysis for RLC circuit design – Flow meters – Pyrometers–Piezo-electric transducers – hall effect transducer.

CO5: outline the significance of computer-based data acquisition and digital display devices. **L:9, P:4**

CO10: utilize smart system for parameter measurement and monitoring using digital technology

Quantization – Digital voltmeters – Ramp and integrating –Digital multimeter –Digital storage Oscilloscope –Digital printers –Data acquisition system – Display devices: LCD, LED, OLED –Smart monitoring: Multifunction meter, Virtual instrumentation - ELVIS Data acquisition experiment in LabVIEW platform - Introduction to IoT technology - Remote monitoring experiment using IoT technology.

TEXT BOOKS:

1. Ernest O. Doebelin , Dhanesh N. Manik, "Measurement Systems", 7th Edition, McGraw Hill Education, 2019.
2. Prithwiraj Purkait, Budhaditya Biswasm Santanu Das, Chiranjib Koley, "Electrical and Electronic Measurements and Instrumentation, McGraw Hill Education, 2017.

REFERENCES:

1. Arthur Whitmore Smith, "Principles of Electrical measurements", Legare Street Press, 2022.
2. A.K.Sawhney, "A Course in Electrical and Electronic Measurements and Instrumentation", Shree Hari Publications, 2021.
3. Kalsi. H.S, "Electronic Instrumentation", Tata McGraw Hill, 4th Edition 2019.
4. Alan S.Morris, Reza Langari, "Measurement and Instrumentation Theory and Application", Elsevier, 2012.
5. Helfrick, Albert. D and Copper. W.D, "Electronics Instrumentation and Measurement Techniques", Prentice Hall of India Ltd. & Co, New Delhi, 2010.

NPTEL MATERIAL: https://archive.nptel.ac.in/courses/108/105/108105153/#

L: 45; P: 30; TOTAL: 75 PERIODS

Course Code	ELECTRON DEVICES AND CIRCUITS	L	T	P	E	C
23EE35C		3	1	2	0	5

COURSE OUTCOMES

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

Theory Component

CO1: explain the characteristics and applications of PN junction diode.
CO2: describe the working principle of transistor and design of biasing circuits
CO3: summarize the characteristics of amplifier using BJT and MOSFET
CO4: illustrate the operation of differential and feedback amplifiers circuits
CO5: demonstrate the pulse and power supply circuits using IC's

Practical Component

CO6: demonstrate the characteristics and applications of PN junction diode.
CO7: realize the characteristics BJT and MOSFET under various bias
CO8: develop an amplifier circuit using BJT and MOSFET
CO9: construct the differential and feedback amplifiers.
CO10: build and verify the power supply circuits

CO1: explain the characteristics and applications of PN junction diode.
CO6: demonstrate the characteristics and applications of PN junction diode. **L:9,**

PN Junction diode – Structure, Operation , Experimental verification of V-I characteristics–Equivalent Circuit – Ideal and Practical Diode – Reverse Recovery Time –Logic Gates using Diode – Rectifiers – Half Wave and Full Wave Rectifier with experimental verification – Filters – Zener diode, characteristics– LED –Schottky diode – Photo Diode – Laser diodes–optocouplers – Analysis of data sheet parameters. **T:3, P:6**

CO2: describe the working principle of transistor and design of biasing circuits
CO7: realize the characteristics BJT and MOSFET under various bias **L:9, T:3, P:6**

BJT Structure, - Characteristics of BJT under CB and CE Configuration - Operation – experimental verification of CE, CB, CC Characteristics – Needs of Biasing – Load Line – JFET, MOSFET Structure, - Characteristics of MOSFET and JFET- Operation and Characteristics– Biasing Circuits BJT and MOSFET– experimental verification of Design of Transistor Biasing - Analysis of data sheet parameters – UJT Structure and characteristics.

CO3: summarize the characteristics of amplifier using BJT and MOSFET
CO8: develop an amplifier circuit using BJT and MOSFET **L:9, T:3, P:6**

BJT small signal model – Analysis of CE, CC amplifiers – Frequency response analysis – MOSFET Small signal model– Experimental Verification of Frequency Response of Common Emitter Amplifier - Frequency Response of Common Source MOSFET Amplifier - Analysis of CS and Source follower –Power amplifiers, Class A, B, AB – Cascaded Amplifier – Design and implementation of Power amplifiers - Darlington

CO4: illustrate the operation of differential and feedback amplifiers circuits
CO9: construct the differential and feedback amplifiers. **L:9, T:3, P:6**

Differential amplifier and its experimental verification – Common mode and Difference mode analysis – Advantages of negative feedback – voltage / current, series, Shunt feedback – Positive feedback – Condition for Oscillations, RC phase shift oscillators and experimental verification – Wien bridge, Hartley, Colpitts and Crystal oscillators.

CO5: demonstrate the pulse and power supply circuits using IC's
CO10: build and verify the power supply circuits **L:9, T:3, P:6**

Pulse circuits – RC integrator and differentiator – Diode Clipping & Clamping circuits – Zener Diodes as Regulators – experimental verification of Design of Zener Voltage regulator - IC voltage regulators – LM78XX, 79XX – Variable voltage regulators switching regulators LM317, LM723 – experimental verification of Design of switching regulators - Linear Mode Power Supply – Switched Mode Power Supply

TEXT BOOKS:

1. Donald.A. Neamen, "Electronic Circuit Analysis and Design", 2nd Edition, Tata McGraw Hill, 2009.
2. Millman.J and Halkias.C, "Electronic Devices and Circuits", 4th Edition, McGraw Hill Education, 2017.

REFERENCES:

1. Robert L. Boylestad and Louis Nashelsky, "Electronic Devices and Circuit Theory", 11th Edition, Prentice Hall, 2015.
2. Thomas L. Floyd and David M.Buchla, "Electronics Fundamentals: Circuits, Devices and Applications", 8th Edition, Pearson College Div, 2010.

3. David A. Bell, "Fundamentals of Electronic Devices and Circuits", Oxford University Press, 2009.
3. Schilling and Belove, "Electronic Circuits", TMH, 3rd Edition, 2002.
4. Chenming Hu, "Modern Semiconductor Devices for Integrated Circuits", Prentice Hall, 2009

L: 45; T:15; P: 30; TOTAL: 90 PERIODS

23GN03C	INTELLECTUAL PROPERTY RIGHTS STUDY	L	T	P	E	C
	(Common to all B.E. / B.Tech. Degree Programmes)	**0**	**0**	**0**	**4**	**2**

COURSE OUTCOMES

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

Experiential Component

CO1: Survey and practice the basic elements of existing patents.

CO2: Investigate and present the state of art technologies through effectual IP search.

Soft Skill Component

CO3: Present patent survey conclusions

CO1 Survey and practice basic elements of existing patents 30

Basic elements of IPR – claims – infringements – Patent examination and Report - Case studies: patent survey.

CO2 Investigate and present the state of art technologies through effectual IP search 30

Importance of IP search-factors to be considered for effective IP search-Hands-on Practice

REFERENCES

1. D.P. Mittal, "Indian Patents Law and Procedure", Taxman Publication, 2002
2. B.L. Wadera, "Patents, trademarks, copyright, Designs and Geographical Judications", 2010
3. P. Narayanan, "Intellectual Property Law", Eastern Law House, 2022
4. N.S. Gopalakrishnan & T.G.Agitha, "Principles of Intellectual Property", Eastern Book Company, Lucknow, 2009.

E:60 TOTAL:60 PERIODS

Course Code	APTITUDE EXCELLENCE	L	T	P	E	C
23GN04C		**0**	**0**	**2**	**0**	**1**

COURSE OUTCOMES

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

CO1: Infer appropriate methods to simplify computation

CO2: Develop problem solving skills on Time and Work and enhance arithmetic ability

CO3: Interpret fundamentals in quantitative techniques and solve problems quickly

CO4: Improve quantitative skills and solve problems on permutation and Combination

CO5: Acquire the knowledge of Cognitive ability and solve puzzles effectively

CO1: Infer appropriate methods to simplify computation

Simplification: Nested Series simplification(fraction) -BODMAS rule – Viraculum (or Bar) rule – Modulus of a real number –Multiplication shortcuts -Comparing Fractions-Data Sufficiency **P:6**

CO2: Develop problem solving skills on Time and Work and enhance arithmetic ability

Time and Work: Work Done - Days from Work:- Ratio – Efficiency –Work and wages - Data Sufficiency **P:6**

CO3: Interpret fundamentals in quantitative techniques and solve problems quickly

Time Speed Distance: Body moving in the same direction- Body moving in the opposite direction-Average speed- Meeting point - Data Sufficiency **P:6**

CO4: Improve quantitative skills and solve problems on permutation and Combination

Probability Permutation Combination: Fundamental Counting Principle – Computing Permutation – Circular Permutation – Computing Combinations - Data Sufficiency **P:6**

CO5: Acquire the knowledge of Cognitive ability and solve puzzles effectively

Abstract reasoning: Mirror and water image – Figure Matrix –Pattern Completion – Logical puzzles – Dot situation - Ranking ordering. **Cognitive ability:** Blood Relation - Direction Sense Test-Data Sufficiency **P:6**

REFERENCES

1. R.V.Praveen, "Quantitative Aptitude and Reasoning", 3rd Edition , Eastern Economy Edition, PHI Learning 2016
2. Arun Sharma," Quantitative Aptitude for CAT", McGraw Hill Edge, 10th Edition 2022
3. Dr.R.Aggarwal, " Quantitative Aptitude", S Chand Publishing, Revised Edition 2017

P:30; TOTAL: 30 PERIODS

Course Code	SIGNALS AND SYSTEMS	L	T	P	E	C
23EE41C		3	0	0	0	3

COURSE OUTCOMES

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

CO1: analyze the types and properties of different signals and systems
CO2: utilize the different mathematical approaches for the behavior of CT and DT LTI systems
CO3: demonstrate the behavior of CT signals and systems in complex frequency domain
CO4: demonstrate the behavior of DT signals and systems in complex frequency domain
CO5: describe the concept of sampling and applications of signals and systems

CO1: analyze the types and properties of different signals and systems **L:9**

Signals: Types – Properties: periodicity, absolute integrability, determinism and stochastic character – Basic Signals: unit impulse, unit step, sinusoid, complex exponential and time-limited signals - continuous and discrete time signals.

Systems: continuous and discrete time systems – Properties: additively and homogeneity, shift-invariance, causality, stability, realisability – Simulation of basic

signals and basic operation on signals.

CO2: utilize the different mathematical approaches for the behavior of CT and DT LTI systems **L:9**

Impulse response and step response – convolution - input-output behavior – cascade interconnections - Characterization of causality and stability of LTI systems – correlation - System representation through differential equations and difference equations – the notion of a frequency response and its relation to the impulse response - block diagram representation - State-space Representation of systems - State-Space Analysis – Simulation of time response of system.

CO3: demonstrate the behavior of CT signals and systems in complex frequency domain **L:9**

Fourier series representation of periodic signals - Waveform Symmetries - Calculation of Fourier Coefficients. Fourier Transform - convolution/multiplication and their effect in the frequency domain - magnitude and phase response - Fourier domain duality. Laplace Transform for continuous time signals and systems - system functions - poles and zeros of system functions and signals - Laplace domain analysis -solution to differential equations and system behavior – Simulation using CT signals in complex frequency domain

CO4: demonstrate the behavior of DT signals and systems in complex frequency domain **L:9**

Discrete-Time Fourier Transform (DTFT) and Discrete Fourier Transform (DFT) - Parseval's Theorem. Z-transform for discrete time signals and systems - system functions - poles and zeros of systems and sequences – z domain analysis - solution to difference equations and system behavior- Simulation using DT signals in complex frequency domain

CO5: describe the concept of sampling and applications of signals and systems **L:9**

Analog to Digital Conversion - Sampling Theorem and its implications - Spectra of sampled signals – Aliasing and its effects - Digital to Analog Conversion – Reconstruction with ideal interpolator, zero-order hold, first-order hold – power spectral density - modulation for communication, filtering, feedback control systems.

TEXT BOOKS:

1. A. V. Oppenheim, A. S. Willsky and S. H. Nawab, “Signals and systems”, Prentice Hall India, 2nd Edition, 2015.
2. J.G.Proakis and D.G.Manolakis, “Digital Signal Processing: Principles, Algorithms, and Applications”, Pearson Education, 4th Edition, 2014.

REFERENCES:

1. H. P. Hsu, “Signals and systems”, Schaum’s series, McGraw Hill Education, 3rd Edition, 2013.
2. S. Haykin and B. V. Veen, “Signals and Systems”, Wiley India Pvt.Ltd, 2nd Edition, 2021.
3. A. V. Oppenheim and R. W. Schafer, “Discrete-Time Signal Processing”, Pearson Education India, 3rd Edition, 2014.

4. M. J. Robert and Govind Sharma "Fundamentals of Signals and Systems", McGraw Hill Education, 2nd Edition, 2017.
5. B. P. Lathi, "Principles of Linear Systems and Signals", Oxford University Press, 2nd Edition, 2009.

L: 45; TOTAL: 45 PERIODS

Course Code	POWER SYSTEM-I	L	T	P	E	C
23EE42C		3	1	0	0	4

COURSE OUTCOMES

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

CO1: demonstrate the fundamental concept of Power system
CO2: evaluate the electrical parameters of the transmission line
CO3: analyze the performance of Transmission line
CO4: analyze the performance of the insulators and cables
CO5: employ the concept of mechanical design of overhead line and substation

CO1: demonstrate the fundamental concept of Power system **L:9,T:3**

Evolution of Power system- Structure of Power system - Generation: Conventional and Non-Conventional Energy Sources (Qualitative Treatment only)-Transmission and Distribution Systems: Types - AC and DC distribution System- Recent Trends in Power System- Synchronized Grid- Smart Grid - Distributed Generation-Pooling station.

CO2: evaluate the electrical parameters of the transmission line **L:9,T:3**

Overhead Transmission Lines : Types of Circuits-Single and Double circuit lines-Electrical and Magnetic Fields in and around the conductors – Lumped and distributed Parameters of single and three phase transmission lines with single and double circuits - stranded and bundled conductors – Symmetrical and Unsymmetrical Spacing-Self and Mutual GMD-Skin Effect and Proximity effects

CO3: analyze the performance of Transmission line **L:9,T:3**

Classification of lines – Short, medium and long transmission line :Equivalent circuits, attenuation constant – Phase constant – Transmission efficiency and voltage regulation-Surge impedance loading– Ferranti effect and corona loss-Tuning of transmission line : Introduction to FACTS devices.

CO4: analyze the performance of the insulators and cables **L:9,T:3**

Insulators-Types of Insulators-voltage distribution in insulator string-improvement of string efficiency-Underground cables: Types of cables, Parameters of cables-Dielectric stress-Grading of cables-Methods of laying-Capacitance of 3-core belted cable.

CO5: employ the concept of mechanical design of overhead line and substation **L:9,T:3**

Mechanical design of transmission line -sag and tension calculations for different weather conditions – Tower spotting – Types of towers
Sub-station Layout (AIS and GIS) - Equipment of Substation-– Bus-bar arrangements-Methods of Grounding- Key diagram of 220 kV/11kV and 11kV/415V Substation - Substation Automation (Qualitative Treatment only).

TEXT BOOKS:

1. Wadhwa C.L., "Electric Power Systems", New Age International (P) Ltd., 6th Edition, 2018.
2. Kothari D.P. and Nagrath I.J., "Power System Engineering", Tata McGraw Hill Private Limited, New Delhi, 3rd Edition, 2019.

REFERENCES:

1. Mehta V. K. and Rohit Mehta, "Principles of Power System", S.Chand Company & Ltd, New Delhi, 2018.
2. Singh S.N., "Electric Power Generation, Transmission and Distribution", Prentice Hall Private Limited, New Delhi, 2008.
3. S Rama Subbanna and B Loveswara Rao, "Electric Power Transmission and Distribution", Notion Press, 2019.
4. J.Grainger and W.D.Stevenson, "Power System Analysis", McGraw Hill Education, 1st Edition, 2017.
5. Hadi Saadat, "Power System Analysis", Tata McGraw Hill Private Limited, 3rd Edition, 2011.
6. B. M. Weedy, B. J. Cory, N. Jenkins, J. Ekanayake and G. Strbac, "Electric Power systems", 5th Edition, Wiley, 2013.

L: 45; T:15; TOTAL: 60 PERIODS

Course code	ENVIRONMENTAL SCIENCE AND ENGINEERING	L	T	P	E	C
23MC02C		2	0	0	0	0

COURSE OUTCOMES:

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

CO1: explain the structure and functions of an ecosystem and the importance of biodiversity.

CO2: interpret the causes, effects of air and water pollution.

CO3: comprehend the causes, impacts and management of e-waste and municipal waste.

CO4: apply the knowledge of sustainability practices in the environment.

CO1: explain the structure and functions of an ecosystem and the importance of biodiversity. **L-6**

Introduction to Environment**,** scope and importance of environment – need for public awareness. Eco-system: structure and function. Biodiversity: Introduction - types – values of biodiversity – threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts – endangered and endemic species of India. Conservation of biodiversity: In-situ and ex-situ - Biodiversity index calculation (Simpson and Shannon diversity Index, Sorenson coefficient)

CO2: interpret the causes, effects of air and water pollution. **L-6**

Air pollution - Classification of air pollutants – sources – Effects - Measurements: dust monitor – gas analyzer, particle size analyzer. Water pollution – Classification – health hazards – sampling and analysis of water. Waste water treatment – different industrial effluents and their treatment – Measurement: BOD and COD – atomic absorption spectrometer. Case study (Okhla sewage water treatment plant)

CO3: comprehend the causes, impacts and management of e-waste and municipal waste. **L-12**

Integrated Waste Management: Introduction – Generation and types of solid waste – Swachh Bharat Mission – Solid waste management: collection, transportation, segregation and processing – Disposal: landfill – biochemical processes and energy recovery - Municipal solid waste management rules 2016.

e-Waste Management: Introduction – Composition - Types – Generation – Environmental and health hazards of e-waste – Recycling - Recovery of metals: pyrometallurgical, hydrometallurgical, and biometallurgical process – e-waste management and handling rules 2016 – e-waste management companies in India.

CO4: apply the knowledge of sustainability practices in the environment. **L-6**

Sustainability and Management**:** Introduction - concept, needs and challenges –economic and social aspects of sustainability – unsustainability to sustainability –millennium development goals and protocols – Sustainable Development Goals-targets, indicators and intervention areas – Climate change – Global, Regional and local environmental issues and possible solutions – case studies. Concept of Carbon Credit – Carbon Footprint – Environmental management in industry – A case study – Zero waste and R concept – Circular economy – ISO 14000 Series – Material Life cycle assessment.

TEXT BOOKS:

1. Miller. G.T and Spoolman. S, 'Environmental Science', 16th Edition, Brooks/Cole Publishing Co., 2018.
2. Peavy. H.S, Rowe. D.R and Tchobanoglous. G, "Environmental Engineering", 2nd Edition, McGraw Hill Education, 2020.
3. Benny Joseph, 'Environmental Engineering', Tata-Mc-Graw Hill, New Delhi, 2016.
4. Gilbert M. Masters, 'Introduction to Environmental Science and Engineering', 2nd Edition, Pearson Education, 2016.

REFERENCES:

1. Kaushik. A and Kaushik. C.P, 'Environmental Science and Engineering', 6th Edition, New Age International Publishers, 2018.
2. Weller. K, 'Environmental Science and Biological Engineering', 1st Edition, WIT Press, 2015.

L:30; TOTAL : 30 PERIODS

Course Code	AC ROTATING MACHINES	L	T	P	E	C
23EE43C		3	0	2	0	4

COURSE OUTCOMES

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

Theory Component

CO1: demonstrate the performance characteristics of synchronous generators.

CO2: employ different starting methods and explain the performance characteristics of synchronous motors.

CO3: relate the performance of the Induction Machines using phasor diagrams

CO4: use the induction motors for suitable applications and pre-determine the performance of AC

motors

CO5: show the principle of operation and performance of single-phase induction motors.

Practical Component

CO6: validate the performance and regulation of alternators using of various direct and indirect method.

CO7: estimate the performance of synchronous motors for different power factors.

CO8: perform the load test of induction motors

CO9: predict the performance characteristics of three phase induction motors

CO10: demonstrate the performance of single phase induction motors.

CO1:demonstrate the performance of synchronous generators **L:9,P:8**

CO6: validate the performance and regulation of alternators using of various direct and indirect methods.

Construction - types - Slots, Coils, concentrated and distributed winding - Winding Factors - EMF Equation - Armature Reaction –experimental verification of Voltage Regulation methods EMF, MMF, ZPF and ASA Methods - Regulation of Three Phase Alternator for resistive, inductive and capacitive loads. - Synchronization of Alternator with bus bars by dark lamp method - Synchronizing power - Parallel Operation - Salient pole machine: Two reaction theory – experimental verification of Slip test - Phasor Diagrams & Voltage Regulation.

CO2: employ different starting methods and explain the performance characteristics of synchronous motors. **L:9,P:2**

CO7: estimate the performance of synchronous motors for different power factors

Principle of Operation - Methods of Starting - Phasor Diagrams - Current loci for constant power input, constant excitation and constant power developed - Power Flow Equations - Effect of Varying load angle and excitation - V and Inverted V Curves with experimental verification - Synchronous Condenser - Hunting and Suppression Techniques.

CO3: relate the performance of the Induction Machines using phasor diagrams **L:9,P:6**

CO8: perform the load test of induction motors

Types - Construction - MMF in Distributed AC Windings - Rotating Magnetic Field - Principle of Operation - Torque equation - Slip-Torque Characteristics –Load test with experimental verification- Phasor Diagram – Losses and efficiency –Separation of No load Losses with experimental verification - Starters - Induction Generators - Doubly-Fed Induction Machines - Generators in Wind turbine – Selection of drives for Induction Motor (Qualitative treatment).

CO4: use the induction motors for suitable applications and pre-determine the performance of AC motors **L:9,P:8**

CO9: predict the performance characteristics of three phase induction motors

No-Load and Blocked Rotor Tests - Circle Diagram, Equivalent Circuit with experimental verification - Cogging and Crawling - Speed Control - Braking – Selection of motors – Applications for electric locomotives and conveyors (Qualitative Case Study).

CO5: show the principle of operation and performance of single-phase induction motors. **L:9,P:6**

CO10: demonstrate the performance of single phase induction motors.
Construction - Principle of operation - Double Revolving Field Theory - Equivalent Circuit, load test with experimental verification - Methods of Starting - Types: Split phase, Capacitor type, Shaded pole, AC series motor and Universal Motor.

TEXT BOOKS:

1. J. Nagrath and D. P. Kothari, "Electric Machines", Mc-Graw Hill Education, 5th Edition, 2017.
2. Theraja. B.L, Theraja. A.K, "A text book on Electrical Technology", Volume–II, S. Chand Company and Ltd, 2014.

REFERENCES:

1. A.E.Fitzgerald, Charles Kingsley, Jr, Stephen D Umans, "Electric Machinery'", Tata McGraw Hill Education, 5th Edition, 2017.
2. Chapman, Stephen J, "Electric machinery fundamentals", Tata McGraw Hill Education, 5th Edition, 2012.
3. M. G. Say, "Performance and design of AC machines", CBS Publishers, 2002.
4. P. S. Bimbhra, "Electric Machines", Khanna Publishers, 2nd Edition, 2017.
5. P.C.Sen, "Principles of Electric Machines and Power Electronics", John Wiley & Sons, 2007.
6. Mehta. V.K and Rohit Mehta, "Principle of Electrical Machines", S. Chand Publishers, 2014.
7. Sudipta Chakraborty, Marcelo G. Simes, and William E. Kramer, "Power Electronics for Renewable and Distributed Energy Systems: A Sourcebook of Topologies, Control and Integration", Springer Science & Business, 2013.
8. Rashid.M.H "Power electronics Hand book", Academic press, 2001.
9. Gopal K. Dubey, "Fundamentals of Electrical Drives", Narosa Publishing House, 2nd Edition, 2001.
10. Gray, L. Johnson, "Wind Energy System", Prentice Hall INC, 1995.
11. Haitham Abu-Rub, Mariusz Malinowski, Kamal Al-Haddad. Power Electronics for Renewable Energy Systems, Transportation and Industrial Applications, 2014, A co-publication of IEEE Press and John Wiley & Sons Ltd.

L: 45; P:30; TOTAL: 75 PERIODS

Course Code	LINEAR INTEGRATED CIRCUITS	L	T	P	E	C
23EE44C		3	1	2	0	5

COURSE OUTCOMES

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

Theory Component

CO1: Explain the monolithic IC fabrication process
CO2: Apply the characteristics of operational amplifier
CO3: Adapt operational amplifier for various applications

CO4: Summarize the applications of op-amp in analog/digital conversions
CO5: Implement the functions of special ICs and Timer

Practical Component

CO6: Realize the characteristics and applications of an op-amp
CO7: Construct the various application circuits of an op-amp
CO8: Build the the applications of op-amp in analog/digital conversions
CO9: Demonstrate the working of special ICs and Timer

CO1: Explain the monolithic IC fabrication process **L:9**

Advantages of IC over discrete components - Classification, manufacturing process of monolithic IC- Wafer preparation, epitaxial growth, masking and etching - Study of monolithic IC Fabrication Process and types- Fabrication of diodes, Monolithic Resistors and capacitor – Complementary MOSFET – Recent trends in IC packaging - Chip testing (qualitative treatment only)

CO2: Apply the characteristics of operational amplifier **L:9,T:4, P:8**
CO6: Realize the characteristics and applications of an op-amp

Operational amplifier stages - Current mirror and current sources - Current sources as active loads - Ideal op-amp characteristics, DC characteristics, AC characteristics – Experimental verification of op-amp characteristics - Measurement of input impedance and loading effect - Inverting and non-inverting amplifiers, voltage follower, Adder, Subtractor with experimental verification.

CO3: : **Adapt operational amplifier for various applications** **L:9, T:4, P:8**
CO7: Construct the various application circuits of an op-amp

Integrator and differentiator with experimental verification - Sign Changer, scale shanger - V-to-I and I-to-V converters - Differential amplifier, instrumentation amplifier, comparators with experimental verification - Schmitt trigger and triangular wave generator – Astable, monostable, and bistable multivibrator - Precision rectifier.

CO4: Summarize the applications of op-amp in analog/digital conversions **L:9, T:4, P:8**
CO8: Build the the applications of op-amp in analog, digital conversions.

Active filters, oscillators (Wein bridge and phase shift) with experimental verification - Peak detector, S/H circuit - Analog and Digital Conversions with experimental verification - D/A converter, specifications, weighted resistor type, R-2R Ladder types - A/D Converters, specifications, Flash type, counter type, servo tracking type, successive approximation type, dual slope type

CO5: Implement the functions of special ICs and Timer **L:9, T:3, P:6**
CO9: Demonstrate the working of special ICs and Timer

Timer IC 555 - Description and functional diagram - Monostable, astable and bistable operation with experimental verification – Schmitt trigger - Monolithic PLL IC 565 - Voltage controlled oscillator IC566 – Audio power amplifier (LM380) circuit with experimental verification – Opto coupler circuits.

TEXT BOOKS:

1. Sergio Franco, "Design with operational amplifiers and analog integrated circuits", 3rd Edition, McGraw Hill Education, 2017.

2. D.Roy Choudhry, Shail Jain, "Linear Integrated Circuits", New Age International Private Limited, 4th Edition, 2017.

REFERENCES:

1. Paul R. Gray, Paul J. Hurst, Stephen H. Lewis and Robert G. Meyer, "Analysis and Design of Analog Integrated Circuits", John Wiley & Sons Inc, 5th Edition, 2009.
2. S.Salivahanan & V.S.Kanchana Bhaskaran, "Linear Integrated Circuits", McGraw Hill Education, 2nd Edition, 2017.
3. Ramakant A. Gayakwad, "Op-amps and Linear Integrated Circuits", Pearson Publication, 4th Edition, 2016.
4. K.R. Botkar, "Integrated Circuits", Khanna Publishers, 5th Edition, 2010.

L: 45; T:15; P: 30; TOTAL: 90 PERIODS

Course Code	DIGITAL ELECTRONICS	L	T	P	E	C
23EE45C		3	1	2	0	5

COURSE OUTCOMES

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

Theory Component

CO1: examine the structure of number system and Selection of Logic family for its application in digital design.

CO2: Analyze and design a simple combinational circuit using logic gates for digital applications and realize the characteristics of flip flops.

CO3: Analyze and design a sequential logic circuit using flip flops and logic gates.

CO4: Analyze and design an asynchronous logic sequential circuit using flip flops and logic gates and illustrate the programmable logic devices.

CO5: develop the programming skill for the digital circuit design using VHDL

Practical Component

CO6: verify the TTL type of Logic gates and minimize the Boolean function using K-Map Method

CO7: investigate and implement the combinational circuit using Logic gates and realize the characteristics of flip flops

CO8: Demonstrate the synchronous sequential circuit like using flip flops

CO9: execute VHDL programming for combinational circuit and sequential circuit

CO1: examine the number system and Utilize appropriate logic gates for digital design. **L:9,T:3, P:4**

CO6: verify the TTL type of Logic gates and minimize the Boolean function using K-Map Method

Review of Number System – complements- Boolean Algebra – Representation of Logic Function – Minimization by Karnaugh Map & Quine McCluskey Method – Implementation of Boolean Functions - Logic Families: Characteristics, ECL, TTL, NMOS & CMOS. Experimental Verification of TTL Logic gates- future trends in transistors.

CO2: Analyze and design a simple combinational circuit using logic gates for digital applications and realize the various flip flops. **L:9,T:3,**

CO7: investigate and implement the combinational circuit using Logic gates and realize the various flip flops. **P:8**

Analyze and Design Combinational Circuits: Adder, Subtractor, and Code Converter, Multiplexer & Demultiplexer, Encoder & Decoder, Comparator, Seven Segment Display and Design of Parity Checker. Flip Flops: SR, JK, D and T Flip flops, master slave flip flop and Realization of Flip Flop.

CO3: Analyze and design a sequential logic circuit using flip flops and logic gates.
CO8: Demonstrate the sequential circuit using flip flops **L:9,T:3, P:6**

Clocked sequential circuit – Moore Model, Mealy Model – State Diagram – State Assignment Analysis and Design – State Reduction – Design and implementation of Counter: Synchronous/ Asynchronous Counter and its applications – Design and implementation Shift Registers and its applications.

CO4: Analyze and design an asynchronous logic sequential circuit using flip flops and logic gates and illustrate the programmable logic devices.
CO8: Demonstrate the sequential circuit using flip flops **L:9,T:3, P:6**

Analysis and Design: Pulse mode & Fundamental mode asynchronous sequential logic circuit – State Assignment – State Diagram –Finite state Machine - Hazards – classification and characteristics of memories, read only memory (ROM), read and write memory (RAM), SRAM, DRAM, Programmable Logic Devices - FPGA.

CO 5: develop the programming skill for the digital circuit design using VHDL.
CO9: execute VHDL programming for combinational circuit and sequential circuit **L:9,T:3, P:6**

Structure of VHDL module – Data Types and Operators –Behavioral Description – Data flow Description –Structural Description –VHDL Description: Flip Flops, Counter, Shift Register – VHDL coding for simple Combinational and sequential circuits.

TEXT BOOKS:

1. Morris Mano. M Michael D. Ciletti, "With an Introduction to the Verilog HDL, VHDL, and System Verilog, ", 5th Edition, Pearson Education, 2018.
2. Donald P. Leach, Albert Paul Malvino, Goutam Sha, "Digital Principles and Applications", 9th Edition, Tata Mc-Graw Hill Private Limited, 2018.
3. Jayaram Bhasker, "VHDL Primer", Prentice Hall, 2017

REFERENCES:

1. Thomas L. Floyd, "Digital Fundamentals", 10th Edition, Pearson College Div, 2017.
2. Salivahanan. S and Arivazhagan. S, "Digital Circuits and Design", 6th Edition, Vikas Publishing House Private Limited, 2020.
3. Charles H. Roth, "Fundamentals Logic Design", 10th Edition, Jaico Publishing House, 2021.
4. John F. Wakerly, "Digital Design Principles and Practice", 6th Edition, Pearson Education, 2019.
5. Ronald J. Tocci, "Digital Systems: Principles and applications", 11th Edition, Pearson Education, 2020.
6. Raj Kamal, "Digital systems –Principles and Design", 2nd Edition, Pearson Education, 2019. Charles H.Roth. "Fundamentals of Logic Design", 6th Edition, Thomson Learning, 2021.

L: 45; T:15; P: 30; TOTAL: 90 PERIODS

Course Code	SYSTEM MODELLING PROJECTS	L	T	P	E	C
23EE46C		0	0	2	2	2

COURSE OUTCOMES

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

Practical component:

CO1: Apply basic mathematics, science, and engineering concepts to develop models for systems or products across various domains.

Experiential component:

CO2: Develop and analyze models using fundamental principles to solve real-life problems.

Soft skill component:

CO3: Develop the ability to work collaboratively in teams to model and simulate systems while effectively communicating technical results using suitable tools and techniques

COURSE OVERVIEW

This course is designed to equip students with the skills to develop and analyze mathematical models for various systems across different domains. It focuses on applying fundamental principles of mathematics, science, and engineering to represent and predict the behaviour of these systems. Through hands-on experience, students will learn to create robust models that address real-world challenges, ranging from system optimization to problem-solving in practical applications. The course emphasizes integrating theoretical concepts with practical solutions, preparing students to design efficient and effective models promoting technical excellence and professional growth.

P: 30; E: 30; TOTAL: 60 PERIODS

Course Code	CONTROL SYSTEMS	L	T	P	E	C
23EE51C		3	0	2	0	4

COURSE OUTCOMES

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

Theory Component

CO1: Develop the transfer function model representation of a given system.
CO2: Analyze the stability of the system with time domain specifications.
CO3: Illustrate the correlation of time domain and frequency domain specifications.
CO4: Determine the state space model for a physical system with its time domain representation.
CO5: Distinguish and design compensator and controller for a system model.

Practical Component

CO 6: Develop the Transfer Function Models for Electro-Mechanical Systems.
CO 7: Design electrical system for evaluating the time domain behavior and its stability margin.
CO 8: Analyze the stability of system using frequency response of the system.
CO 9: Develop the State model for the Electro-Mechanical Systems.
CO10: Design compensator and controller for given time and frequency domain specifications.

L:9, P:6

CO1: Develop the transfer function model representation of a given physical system

CO6: Develop Transfer Function Models for Electro-Mechanical Systems

Systems - open and closed loop systems - Modelling: electrical, opamp circuits,

mechanical and electro-mechanical systems - Mathematical modeling of armature controlled and Field controlled DC motor - Determination of Transfer function of AC servomotor- Electric Circuit Analogy - Reduction of multiple subsystems: Block Diagram Reduction-Signal Flow Graph

CO2: Analyze the time domain behavior and stability of the given system **L:9, P:6**
CO7: Demonstrate the time domain behavior of an electrical system.

Standard test signals - Time response of first and second order systems and its simulation and validation - Steady State Error - Generalized error series - Characteristic equation – Routh Hurwitz Criteria- Construction of Root-loci- Effect of addition of poles and Zeros - Stability Analysis of linear system using root locus Technique.

CO3: Analyze the frequency domain behavior and stability margin of the given system **L:9, P:6**
CO8: Analyze the stability of system using frequency response of the system.

Frequency domain specifications -Correlation between time domain and frequency domain –Open loop frequency response: Bode Plot - Polar Plot -Frequency response analysis by using Bode Plot and polar plot- Closed loop frequency response: M and N circles, Nichol's chart, Nyquist Stability Criteria

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CO4:Determine the state space model for a physical system with its time domain representation **L:9, P:4**
CO9: Demonstrate the state model for the electromechanical system

State Space model Representation – State space from transfer function -Signal Flow Graphs of State equations – Realization - Model representation of Inverted Pendulum– Solution of state equations - controllability and observability– stability– Kinematic model of Robotic system.

CO5: Design a suitable compensator/controller for a system **L:9, P:8**
CO10:Demonstrate the design of compensator/controller for the desired time and frequency domain specifications

Compensator network and types - Design of Lag compensator, Lead Compensator and Lag-Lead Compensator using Bode plot -Design of compensators using Simulation software package- Controllers- classification - Ziegler-Nichols based controller design - Design and simulation of PID Controller using Zeigler Nichols Technique-State Feedback controller using pole placement - Design of state feedback controller using Pole placement technique.

TEXT BOOKS:

1. Nagrath I.J and Gopal M., "Control Systems Engineering", New Age International Publishers, 5th Edition (Reprint), 2016.
2. Norman S. Nise, Control Systems Engineering, 8th Edition, John Wiley, 2020.

REFERENCES:

1. Benjamin C. Kuo, "Automatic Control systems", PHI Learning Private Ltd, Jan 2014.
2. K. Ogata, "Modern Control Engineering", 5th Edition, Prentice Hall Private Limited, New Delhi, 2010.

3. Richard.C. Dorf and Robert H. Bishop, "Modern Control Systems", Addison –Wesley, Oct, 2016.
4. Gopal M., "Control Systems: Principles and Design", 4th Edition, Tata Mc-Graw Hill Private Limited, New Delhi, 2012.

L: 45; P: 30; TOTAL: 75 PERIODS

Course Code	POWER SYSTEM- II	L	T	P	E	C
23EE52C		3	0	2	0	4

COURSE OUTCOMES

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

Theory Component

CO1: Draw a reactance diagram and calculate the short circuit current for balanced faults.

CO2: Calculate the short circuit current for an unbalanced fault and conduct transient stability studies on a power system.

CO3: Formulate the Y-Bus matrix and assess the power flow using numerical methods.

CO4: Develop and evaluate a power system's load frequency and economic dispatch control model.

CO5: Apply Computer control to the Power System

Practical Component

CO6: Demonstrate the short circuit studies on a power system for balanced faults.

CO7:Perform short circuit and transient stability analysis in the power system

CO8: Simulate a load flow analysis on a power system using numerical techniques**.**

CO1: Draw a reactance diagram and calculate the short circuit current for balanced faults. **L:9, P:6**

CO6: Demonstrate the short circuit studies on a power system for balanced faults.

Review of structure of power system-Single line diagram-Representation of Generator, Transformer, Transmission line and Load Model-P.U-System-Impedance and Reactance diagram-Realization of Single line diagram using ETAP -Introduction to short circuit Analysis-Balanced three phase Faults-Simulation studies using Matlab/ETAP-Selection of Circuit Breakers

CO-2 Calculate the short circuit current for an unbalanced fault and conduct transient stability studies on a power system. **L:9, P:9**

CO-7:Perform short circuit and transient stability analysis in the power system

Unbalanced Faults: Bus impedance Matrix formation- Realization using bus building algorithm-Symmetrical Components-Sequence Network-Short Circuit Current Calculation(L-G,LL,andLLG fault)-Unbalanced fault simulation using ETAP - Introduction to transient Stability Analysis: Swing Equations of a synchronous machine connected to an infinite bus system- Power angle curve–Equal Area Criterion-Loss of synchronism in a single-machine infinite bus system following a three-phase fault-Transient stability analysis of single machine infinite bus system (SMIB) using MATLAB

CO3: Formulate the Y-Bus matrix and assess the power flow using numerical methods. **L:9, P:9**

CO-8 Perform a load flow analysis on a power system using numerical techniques.

Formation of Bus admittance matrix- Realization in MATLAB-Bus classification - Formulation of Power Flow problem in polar coordinates - Power flow solution using Gauss Seidel method - Handling of Voltage controlled buses - Power Flow solution by Newton Raphson method – Flow charts – Comparison of methods-Realization of Load Flow and Related Problems Using MATLAB/ETAP

CO4: Develop and evaluate a power system's load frequency and economic dispatch control model. **L:9, P:6**

CO-8 Simulate the load frequency and economic dispatch control of the power system

System Load Variation-Load and Load duration Curves-Fundamentals of speed governing mechanism and modeling –Speed-load characteristics – Load sharing – control area-LFC of single and two area systems-Simulation using MATLAB-Economic dispatch problem- with and without loss - Lambda iteration Method-Simulation and validation.

CO5: Apply Computer control to the Power System **L:9**

Need of computer control of power system -Energy Control Centre and their functions-SCADA systems –Hardware Configurations-Various operating states of a Power System-State-estimation- Preventive and Emergency Control- Intelligent Electronic devices (IED)-Phasor Measurement Units (PMU)–Wide Area Monitoring, Protection and Control(WAMPAC) -Bay Control Unit.

TEXT BOOKS:

1. D.P.Kothari, I J Nagrath and R K Saket ‘ModernPower System Analysis’, McGraw Hill Education Pvt. Ltd., New Delhi, 5th Edition 2022.
2. J. Grainger and W.D.Stevenson, “Power System Analysis”, McGraw Hill Education, July 2017.
3. Allen. J. Wood and Bruce F. Wollen berg, ‘Power Generation, Operation and Control’, John Wiley & Sons, Inc., 3rd edition, 2013

REFERENCES:

1. Chakrabarti Abhijit and Halder Sunita “Power System Operation and Control”, PHI Learning Pvt. Ltd.; Fourth Edition-July 2022
2. O. I. Elgerd, “Electric Energy Systems Theory”, McGraw Hill Education, 2nd Edition, 2017.

Course Code	MICROPROCESSOR, MICROCONTROLLER AND ITS APPLICATIONS	L	T	P	E	C
23EE53C		3	0	2	0	4

COURSE OUTCOMES

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

Theory Component

CO1: explain the architecture and features of 8 bit microprocessors (8085/8086).

CO2: write programs using instruction sets of 8085 Microprocessor.
CO3: summarize the principles of peripheral interfacing ICs.
CO4: describe the architecture and functions of 8051 microcontroller.
CO5: explain the ARM architecture, configuration and programming

Practical Component

CO6: develop basic arithmetic operations using 8085microprocessor.
CO7: use peripheral ICs to provide solutions to real world problems.
CO8: apply instruction set of 8051 for simple programming and application.
CO9: build simple application interface using ARM microcontroller.

CO1: explain the architecture and features of 8 bit microprocessors (8085/8086). **L:9**

Architecture of 8085 – Pin outs and signals – Memory interfacing – I/O ports and data transfer concepts – Timing Diagram – Interrupt structure – 8086 processor (Architecture and modes of operation only).

CO2: write programs using instruction sets of 8085 Microprocessor. **L:9, P:12**
CO6: develop basic arithmetic operations using 8085microprocessor.

Instruction set and addressing modes – Programming: Loop structure with counting & Indexing – Lookup table – Subroutine instructions – Delay calculations – Experimental verification of arithmetic operations using 8085 microprocessors and ascending / descending order, maximum / minimum of numbers, use of rotate instructions, Hex / BCD code conversions..

CO3: summarize the principles of peripheral interfacing ICs. **L:9, P:6**
CO7: use peripheral ICs to provide solutions to real world problems.

Study of Architecture and programming of ICs: 8255 PPI, 8251 USART, 8279 Key board display controller and 8253 Timer/ Counter – Interfacing with 8085 – A/D and D/A converter – experimental verification of peripheral interfacing ICs – Traffic light interfacing and experimental verification.

CO4: describe the architecture and functions of 8051 microcontroller **L:9, P:6**
CO8: apply instruction set of 8051 for simple programming and application

Functional block diagram of 8051– Memory Structure – Instruction set – Addressing modes – Arithmetical programming – Interrupt structure – Timer – Serial communication. Experimental verification of arithmetic operations using 8051microcontroller, Hex / BCD code conversions – C programming – Digital IO interface – Stepper motor control and D/A converter with Experimental verification.

CO5: explain the ARM architecture, configuration and programming. **L:9, P:6**
CO9: build simple application interface using ARM microcontroller.

Introduction to ARM Architecture – Overview of ARM7TDMI Core – Introduction to LPC2148 Microcontroller – Pin Configuration and Functionality – Ports: configuration and programming –Memory Structure of LPC2148 – ARM7 Register Set – Interrupts and Exceptions – Development Environment and Tools – Experimental verification of GPIO Programming Basics, Peripheral interface.

TEXT BOOKS:

1. Krishna Kant "Microprocessor and Microcontrollers", Eastern Company Edition, Prentice Hall Private Limited, New Delhi, 2013.
2. Senthilkumar N., Saravanan M. and Jeevananthan.S, "Microprocessor and Microcontrollers", Oxford University Press, 2016.

3. Muhammad Tahir and Kashif Javed, 'ARM Microprocessor Systems - Cortex-M Architecture, Programming, and Interfacing', CRC Press, 2017.

REFERENCES:

1. Ankaj Gupta, "Microcontroller and Embedded System", S.K.Kataria and Sons Publishers 2013.
2. Muhammad Ali Mazidi and Janice Gilli Mazidi, Kinely. R, "The 8051 Micro Controller and Embedded Systems (Using Assembly Language and C)", PHI Pearson Education, 2011.
3. Ramesh Gaonkar, "Microprocessor Architecture Programming and Application", CBS Publishers 2011.
4. Walter A Tribal and Avtar Singh, "The 8088 & 8086 Microprocessors", Pearson Education, 2007.
5. Singh B.P. and Renu Singh, "Advanced Microprocessors and Microcontrollers", New Age International Private Limited, 2009.

L: 45; P: 30; TOTAL: 75 PERIODS

Course Code	POWER ELECTRONICS	L	T	P	E	C
23EE54C		3	0	2	0	4

COURSE OUTCOMES

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

Theory Component

CO1: employ the characteristics of power semiconductor devices
CO2: analyze the performance of single-phase and three-phase rectifiers.
CO3: realize the operating principle of hard and soft-switching DC-DC converters.
CO4: comprehend the operation and switching strategies of DC – AC converters
CO5: investigate the operation of AC-AC converters and their performance.

Practical Component

CO6: select an appropriate power semiconductor device for a given converter configuration.
CO7: investigate the performance of fully controlled and half controlled converter.
CO8: demonstrate the operation and control of DC – DC converters
CO9: analyze the performance of single phase and 3 phase inverters.
CO10: perform the operation of AC- AC voltage Controllers and cycloconverters

CO1: employ the characteristics of power semiconductor devices **L:9, P:6**
CO6: select an appropriate power semiconductor device for a given converter configuration.

Basic structure; steady-state and Switching characteristics of power diode, SCR, power MOSFET, IGBT, GTO, IGCT, Experimental Verification of Characteristics of SCR, TRIAC, MOSFET and IGBT, Gate driver and snubber circuits, Intelligent Power Modules (IPM), Introduction to Wide-band gap (SiC and GaN) power devices

CO2: analyze the performance of single-phase and three-phase rectifiers. **L:9, P:6**
CO7: investigate the performance of fully controlled and half controlled converter.

Single phase half and fully controlled converters with R, RL and RLE load, Performance parameters; Experimental Verification of single phase AC to DC fully controlled and half controlled converter Effect of source impedance; Three-phase half

and fully controlled converter with R and RL load, Dual converters, Applications - light dimmer.

CO3: realize the operating principle of hard and soft-switching DC-DC converters. **L:9, P:6**
CO8: demonstrate the operation and control of DC – DC converters

Control strategy, Step-down and step-up chopper, Types of choppers - Buck, Boost, Buck-Boost regulator, Simulation and Experimental Verification of Buck and boost converter – Resonant Converters, fly-back converters; Hard and soft-switching, zero-voltage switching (ZVS) and zero-current switching (ZCS) concepts; Applications- Switched Mode Power Supply.

CO4: Comprehend the operation and switching strategies of DC – AC converters **L:9, P:6**
CO9: Analyze the performance of single phase and 3 phase inverters.

Single phase and three phase voltage source inverters– Voltage & harmonic control - PWM techniques: Multiple PWM, Sinusoidal PWM, selective harmonic elimination – Simulation and Experimental verification of inverters, Introduction to space vector modulation – Single-phase Current source inverter, Applications - UPS.

CO5: investigate the operation of AC-AC converters and their performance. **L:9, P:6**
CO10: perform the operation of AC- AC voltage Controllers and cycloconverters

Single-phase and three-phase AC voltage regulators, Cyclo-converters, Experimental verification of AC Voltage Controllers and cycloconverters, Introduction to Matrix converters, Multi-level inverters.

TEXT BOOKS:

1. Rashid M.H., "Power Electronics: Circuits, Devices and Applications", Pearson Education, Prentice Hall Private Limited, New Delhi, 4th Edition, 2017.
2. Bimbra P.S., "Power Electronics", Khanna Publishers, 7th Edition, 2022.

REFERENCES:

1. Robert W. Erickson and Dragan Maksimovic, "Fundamentals of Power Electronics",Springer, 2018.
2. Ned Mohan, Tore M. Undeland, William P. Robbins, "Power Electronics: Converters, Applications and Design", 3rd Edition, John Wiley and sons, 2014.
3. L. Umanand, Power Electronics: Essentials and Applications", Wiley India, 2014.
4. Singh M.D and Khanchandani K.B., "Power Electronics", 3rd Edition, Tata McGraw Hill Private Limited, New Delhi, 2008.

L: 45; P: 30; TOTAL: 75 PERIODS

Course Code	SIMULATION USING MODERN TOOLS	L	T	P	E	C
23EE55C		0	0	2	2	2

COURSE OUTCOMES

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

Practical Component:

CO1: Develop and simulate mathematical models using simulation software package.

Experiential Component:

CO2: Analyze, validate and interpret the results obtained from a specific real-world system.

Soft skill Component:

CO3: Communicate effectively and work collaboratively as a team to develop projects, present simulation findings, and engage in constructive feedback sessions.

1. Introduction to Modern Simulation Tools **P:30; E:30**
   - ✓ MATLAB/Simulink
   - ✓ PSIM
   - ✓ ETAP (Electrical Transient Analysis Program)
   - ✓ Ansys Maxwell

   The Students are requested to perform any one / combination / interdisciplinary of the real world system using modern simulation models based on the domain interest

   1. Electronics Circuits / Time Domain Analysis / Frequency Response and Bode Plot / Design, Modeling and analysis for desired specifications
   2. Load Flow Analysis / Fault Analysis and Protection Coordination / Stability Analysis
   3. Modeling Dynamic Systems / Time Domain and Frequency Domain Analysis / Design and Analysis of Controllers or Compensators
   4. Modeling Power Electronic Converters / Switching Analysis / Simulation in MATLAB
   5. Introduction to Field Analysis Tools / Electromagnetic Devices Simulation / Finite Element Method (FEM)

Recommended Texts and Resources

- "Introduction to MATLAB for Engineers" by William J. Palm III, 2010.
- "Electrical Power Systems: Concepts, Theory, and Practice" by Kamaraju.
- Simulation tool documentation and tutorials (e.g., ETAP, Ansys Maxwell).
- Richard Dorf , and Robert Bishop, “Modern Control Systems”, Pearson Publication, 13th Edition, 2016.

P: 30; E: 30; TOTAL: 60 PERIODS

Course Code	POWER SYSTEM PROTECTION AND SWITCHGEAR	L	T	P	E	C
23EE61C		3	0	0	0	3

COURSE OUTCOMES

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

Theory Component

CO1: illustrate the basic principles, construction and characteristics of different relays
CO2: Realize the concept of power system grounding and apparatus protection schemes
CO3: Recognize the performance and functions of advanced relays
CO4: analyse the process and execution of circuit breakers
CO5: Comprehend the operation and testing of different types of circuit breakers

CO1: illustrate the basic principles, construction and characteristics of different relays **L:9**

Introduction, Fundamental requirements of protective relaying, Zones of Protection - Primary and Back up Protection - International and Indian standards for protective

systems - Environmental and Sustainability Regulations - Classification of Relays: Electromagnetic Relays-Attracted Armature, Balanced Beam, Induction disc, Thermal Relays - over current, directional and non-directional, distance, negative sequence, differential relays.

CO2: Realize the concept of power system grounding and apparatus protection schemes **L:9**

Alternator Protection - Transformer Protection - Bus bar protection - Feeder protection, pilot wire and carrier current protection, methods of neutral grounding – Insulation co-ordination: Basic Insulation Level (BIL) - Definition – Design of insulation co-ordination for sub-station equipments.

CO3: Recognize the performance and functions of advanced relays. **L:9**

Overview of substation automation - Digital relay, Micro-Processor based relay, Numerical Relay: Block diagram – Intelligent Electronic Devices (IED) - IEC Protocol for Protection equipment Overcurrent protection, transformer differential protection, Motor Protection and distant protection of transmission lines – applications of IED.

CO4: analyse the process and execution of circuit breakers **L:9**

Difference between an isolator and circuit breaker, Basic principle of operation of a circuit breaker, Phenomena of arc, Arc interruption theories - Slepian's theory and Energy balance theory, Restriking voltage, Recovery voltage, Rate of rise of Restriking voltage, DC circuit breaking, AC circuit breaking, Current chopping, Capacitance switching, Resistance switching, – Selection of breakers.

CO5: Comprehend the operation and testing of different types of circuit breakers. **L:9**

DC Circuit breaker, Types of AC Circuit breakers: Oil, Air, Vacuum and SF_6; Alternatives for SF_6 gas – Smart Circuit Breakers - Testing of circuit breakers; Type tests and Routine tests - Concept of Gas Insulated Substation – Standards and Specifications of Various Circuit Breakers (Case Study).

TEXT BOOKS:

1. Badri Ram, D.N. Vishwakarma, and Soumya R. Mohanty, "Power System Protection and Switchgear", McGraw-Hill Education, 3rd Edition, 2022.
2. Sunil S. Rao, "Switchgear Protection and Power Systems (Theory, Practice & Solved Problems)", Khanna Publishers, 13th Edition, 2008.

REFERENCES:

1. B. Ravindranath, M. Chander, and C.S. Jha, "Power System Protection and Switchgear", New Age International Publishers, 2nd Edition, 2011.
2. J.L. Blackburn and Thomas J. Domin, "Protective Relaying: Principles and Applications", CRC Press, 4th Edition, 2014.
3. Y.G. Paithankar and S.R. Bhide, "Fundamentals of Power System Protection", PHI Learning Pvt. Ltd., 2nd Edition, 2022.
4. T.S. Madhava Rao, "Digital/Numerical Relays", Tata McGraw-Hill Education, 1st Edition, 2005.
5. G.Phadke and J. S. Thorp, "Synchronized Phasor Measurements and their Applications", Springer US, 2010

L: 45; TOTAL: 45 PERIODS

Course Code	HIGH VOLTAGE ENGINEERING	L	T	P	E	C
23EE62C		3	0	2	0	4

COURSE OUTCOMES

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

Theory Component

CO1: Apply the principles of overvoltages, lightning protection, and insulation coordination in power systems

CO2: Explain dielectric properties and breakdown mechanisms in various media.

CO3: Apply the principles of high voltage generation to analyze and design HVDC and HVAC systems using rectifiers, multipliers, and transformers.

CO4: Describe the principles behind generation of impulse voltages and current.

CO5:–Demonstrate adaptability in selecting and applying appropriate testing methods for diverse power equipment.

Practical Component

CO6: Analyze breakdown behavior through experiments under different field configurations.

CO7: Demonstrate the generation methods of HVAC and HVDC

CO8: Demonstrate and calibrate impulse generators and showcase the generation of switching surges using Marx circuits.

CO9: Utilize testing techniques for evaluating performance of power system components under high voltage stress.

CO1: Apply the principles of overvoltages, lightning protection, and insulation coordination in power systems **L:9**

Causes of over voltages and its effects on power system – Lightning: Mechanism – harmful Effects – Protection against lightning – Lightning arrester and its types - Insulation Coordination – Statistical approach – Case study: Design of lightning arrester.

CO2: Explain dielectric properties and breakdown mechanisms in various media. **L:9;**
CO6: Analyze breakdown behavior through experiments under different field configurations. **P-8**

Properties of Dielectric materials - Gaseous breakdown in uniform and non-uniform fields – Experimental verification of breakdown in gaseous dielectric - Corona discharges – Vacuum breakdown – Conduction and breakdown in pure and commercial liquids - Experimental verification of transformer oil - Breakdown in mechanisms in solid and composite dielectrics.

CO3: Apply the principles of high voltage generation to analyze and design HVDC and HVAC systems using rectifiers, multipliers, and transformers. **L:9;**
CO7: Demonstrate the generation methods of HVAC and HVDC **P-8**

Generation of HVAC: Cascaded transformer, resonant transformers, high frequency HVAC – Practical Generation of HVAC - Generation of HVDC: Rectifier circuits, Voltage multiplier circuits, Electrostatic machines - Practical Generation of HVDC.

CO4: Describe the principles behind generation of impulse voltages and current.
CO8: Demonstrate and calibrate impulse generators and showcase the generation of switching surges using Marx circuits.

L:9; P-6

Generation of impulse: Theoretical representation – circuits used for impulse, Marx circuit - Practical Generation of Impulse - Generation of switching surges - Tripping and control of impulse generators

CO5: Demonstrate adaptability in selecting and applying appropriate testing methods for diverse power equipment.
CO9: Utilize testing techniques for evaluating performance of power system components under high voltage stress.

L:9; P-8

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

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', Newnes Second Edition, Elsevier , New Delhi, 2005.

REFERENCES:

1. L.L.Alston, High Voltage Technology, Oxford University Press, First Indian Edition 2006.
2. C.L.Wadhwa, High voltage Engineering, New Age International Publishers, Fourth Edition, 2020
3. Mazen Abdel – Salam, Hussein Anis, Ahdab A-Morshedy, RoshdayRadwan, High Voltage Engineering – Theory & Practice,Second Edition, Taylor & Francis Gourp, 2019
4. Subir Ray." An Introduction to High Voltage Engineering "PHI Learning Private Limited, New Delhi, Second Edition-2011

L: 45; P:30; TOTAL: 75 PERIODS

Course Code	OBJECT ORIENTED PROGRAMMING	L	T	P	E	C
23EE63C		2	0	2	2	4

COURSE OUTCOMES

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

Theory Component

CO1: apply the object oriented programming constructs to solve known applications
CO2: design and implement effective access specifications with function overloading for application development
CO3: adopt critical thinking to implement inheritance, dynamic binding and generic nature for code reusability
CO4: develop and solve real-world applications by handling files, streams, and exceptions
CO5: build well-defined, efficient data handling strategies using templates and STL

Practical Component

CO6: demonstrate the basic OO principles such as, class, objects, and overloading
CO7: analyze and solve problems using inheritance, polymorphism and files

Experiential Component

CO8: create contemporary solutions for solving real-world OOP applications

CO1: apply the object oriented programming constructs to solve known applications

Object-Oriented Programming Concepts: Introduction, Comparison between procedural programming paradigm and object-oriented programming paradigm, Features of object-oriented programming: Encapsulation, Class, Object, Abstraction, Data hiding, polymorphism, and Inheritance. Functions and Arrays: Function components, Default arguments, passing parameters, Function prototyping, Call by value, Call by reference, Return by reference, Inline functions, Friend functions. Array of objects. Pointer: Pointer and Function pointer. Memory management : New and Delete, pointers to objects

L:6, P:4, E:3

CO6: demonstrate the basic OO principles such as class, objects, and overloading

programs using data types, control structures, arrays, string, functions and pointers

CO2: design and implement effective access specifications with function overloading for application development

L:5, P:6, E:6

Classes and Objects: Implementation of a class, Creating class objects, Operations on objects, Relationship among objects, Accessing class members, Access specifiers, Constructor and destructor, Types of constructor, Static members, Empty classes, Nested classes, Local classes, Abstract classes, Container classes. Function Overloading, Overloading Constructors, Copy Constructors, Finding the Address of Overloaded Functions, Default Function Arguments, Function Overloading and Ambiguity. Operator overloading: Creating a member Operator Function, Operator Overloading Using Friend Function, Overloading New and Delete, Overloading Special Operators

CO6: demonstrate the basic OO principles such as class, objects, and overloading

programs using class, objects, constructors, destructors and overloading

CO3: adopt critical thinking to implement inheritance, dynamic binding and generic nature for code reusability

L:8, P:6, E:6

Inheritance: Concept of inheritance. Derived class and based class. Derived class constructors, member function, inheritance in the class, class hierarchies, public and private inheritance, aggregation: Classes within classes, inheritance and program development. Polymorphism: Virtual Functions – Virtual Attribute and Inheritance – Virtual Functions and Hierarchy – Pure Virtual Functions – Using Virtual Functions – Early vs. Late Binding. Run-Time Type ID and Casting Operators: RTTI – Casting Operators – Dynamic Cast.

CO7: analyze and solve problems using inheritance, polymorphism and files.

programs using inheritance and polymorphism.

CO4: develop and solve real-world applications by handling files, streams, and exceptions **L:5, P:8, E:8**

Streams and Files: Streams classes, Stream Errors, Disk File I/O with streams, file pointers, error handling in file I/O with member function, command line arguments. Exception handling: Try, throw, and catch, exceptions and derived classes, function exception declaration, unexpected exceptions, exception when handling exceptions, resource capture and release. Case study with real time applications.

CO7: analyze and solve problems using inheritance, polymorphism and files
programs using files and exception handling

CO5: build well-defined, efficient data handling strategies using templates and STL **L:6, P:6, E:7**

Templates: Parameterized types – Parameterized operations – template mechanisms - Generic programming - variadic templates – template compilation model – Applying Generic Functions – Generic Classes – Type name and Export Keywords – Power of Templates. Standard Template Library: Iterators – Auxiliary Iterator function – Algorithms – Non-modifying sequence operations – mutuating sequence operations – Containers: Sequence and associative containers - Algorithms, string class – explicit, mutable and operator keywords. Namespaces: user defined namespaces, namespaces provided by library.

CO8: create contemporary solutions for solving real-world OOP applications

TEXT BOOKS

1. Bjarne Stroustrup, "A Tour of C++", 3rd Edition, Pearson Education, April 2023.
2. Ivor Horton, Peter van, "Beginning C++ 20 from novice to professional", 6th Edition, APRESS media, 2020.
3. Bjorin Andrist, Viktor Sehr, "C++ High Performance: Master the art of optimizing the functioning of your C++ code", 2nd Edition, December 2020.
4. Nicoloai.M Josuttis and Doug Gregor, "C++Templates: Tem complete guide", 1st Edition, 2020.

53.

REFERENCES

1. Reema Thareja, "Object oriented programming with C++", Revised First Edition, Oxford University Press, 2018.
2. E.Balagurusamy, "Object oriented programming with C++", 8th Edition, September 2020.

RECOMMENDED ONLINE COURSES

1. https://onlinecourses.nptel.ac.in/noc23_cs78/preview
2. https://www.udemy.com/course/oops-and-c-from-basic-to-advanced/?utm_source=adwords&utm_medium=udemyads&utm_campaign=WebDevelopment_v.PROF_la.EN_cc.INDIA_ti.8322_Exp&utm_content=deal4584&utm_term=_._ag_82381207618_._ad_533094292056_._kw__._de_c_._dm__._pl__._ti_dsa-774930032289_._li_9148661_._pd__._&matchtype=&gclid=CjwKCAjws7WkBhBFEiwAIi1686CgFnpeYYHiDNs6T6z6Kx84B35ehfI24i021yFk1aB15zGyVz8_bxoC8QEQAvD_BwE
3. https://www.udemy.com/course/crash-course-on-cpp-stl/
4. https://www.coursera.org/lecture/c-plus-plus-b/1-3-standard-template-library-o3v9K

5. https://www.coursera.org/learn/object-oriented-cpp

L: 30; P: 30; E: 30; TOTAL: 90 PERIODS

Course Code	PRODUCT DEVELOPMENT PRACTICE	L	T	P	E	C
23EE64C		0	0	0	4	2

COURSE OUTCOMES

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

Experiential Component

CO1: Identify and analyze real-world problems using empathy techniques and reverse engineering approaches.

CO2: Apply forward engineering to develop innovative solutions, focusing on technical feasibility, patentability, and market potential.

Soft skill component

CO3: Demonstrate the functionality of the developed product through prototypes and validate its commercial and patenting potential.

CO1: Identify and analyze real-world problems using empathy techniques and reverse engineering approaches. **E:25**

Module-1: Problem Identification and Reverse Engineering

- Empathy-driven customer need identification
- Problem definition and market analysis
- Study of existing solutions and reverse engineering analysis
- Deriving specifications and functional gaps
- Conceptual design based on gaps and feasibility

CO2: Apply forward engineering to develop innovative solutions, focusing on technical feasibility, patentability, and market potential. **E:35**

Module-2: Forward Engineering and Product Development

- Concept refinement and solution detailing
- Rough model and Working model prototype development (hardware/software)
- Technical, financial, and IP (intellectual property) feasibility study
- Cost estimation and business model canvas
- Prototype demonstration and product documentation

REFERENCES:

1. Product Design and Manufacturing, Avinash K. Chitale, R. C. Gupta, PHI Learning Pvt. Ltd., 7th Edition, 2022
2. Product Development: A Structured Approach to Consumer Product Development, Design, and Manufacture, Anil Mital, Aashi Mital, Anoop Desai, Anand Subramanian, Elsevier, 2nd Edition, 2014
3. New Product Development, Prithwiraj Nath, Oxford University Press India, 1st Edition, 2014
4. Product Design and Development, Karl T. Ulrich, Steven D. Eppinger, Maria C. Yang, McGraw Hill Education, 7th Edition, 2020

E:60; TOTAL: 60 PERIODS

23EE71C	MINI PROJECT	L	T	P	E	C
		0	0	0	6	3

COURSE OUTCOMES

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

Experiential component:

CO1: Identify and define an engineering problem through need analysis, systematic literature review and feasibility study.

CO2: Develop an appropriate methodology, preliminary design/model, and project plan with required resources and timelines.

Soft skill component:

CO3: Communicate project ideas effectively through structured documentation, teamwork, and technical presentations.

Course content:

Selection of topic/problem based on relevance to industry / society / research, literature review – survey of existing solutions – research papers, identification of gaps, defining the problem clearly. Objectives of the project & scope.

Project Planning, Methodology, Block diagrams, Flow diagrams, Algorithm design, Resource identification, Basic simulation and prototype (if applicable), Life cycle costing.

Structured documentation and Presentation

E:90; TOTAL: 90 PERIODS

23EE81C	CAPSTONE PROJECT/INDUSTRY PRACTICE	L	T	P	E	C
		0	0	0	12	6

COURSE OUTCOMES

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

Experiential component:

CO1: Identify, analyze, and define a significant engineering problem using based on need assessment, literature survey and domain knowledge.

CO2: Apply appropriate engineering methods, design principles, tools, and modern software to develop and implement a solution or prototype with sustainability considerations.

CO3: Conduct experiments, analyze data, evaluate results, and interpret findings with integrity and ethics.

Soft skill component:

CO4: Prepare comprehensive project documentation and effectively present technical results in reputed conferences / journals

Course Content

- Domain Analysis, Problem Identification, Literature Review / Market survey, Methodology, Design and Implementation, Experimental Work / Simulation / Analytical studies / Optimization / Testing, Project Management - Life cycle costing, Documentation & Presentation.

E:180; TOTAL: 180 PERIODS

R-2023 B.E. EEE

PROGRAMME ELECTIVE COURSES

Course Code	AUTONOMOUS INTELLIGENT VEHICLES	L	T	P	E	C
23EE01E		3	0	0	0	3

COURSE OUTCOMES

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

Theory Component

CO1: Relate the essential components of autonomous vehicles and their role in enabling independent navigation.

CO2: Describe the vital role of control in autonomous systems, applying their understanding to discuss real-world applications and implications.

CO3: Examine various types of sensors and their integration within system architecture.

CO4: Employ the various algorithms and techniques utilized in mapping and path planning for autonomous electric vehicles.

CO5: Apply the principles discussed in recent research to real-world scenarios involving autonomous systems.

CO1: Relate the essential components of autonomous vehicles and their role in enabling independent navigation. **L:9**

Introduction to Autonomous Vehicles - Components of Autonomous Vehicles - Levels of Automation in Driving - Operational Models of Autonomous Vehicles - Case Study: Research and Experiments on Autonomous Vehicles

CO2: Describe the vital role of control in autonomous systems, applying their understanding to discuss real-world applications and implications **L:9**

Introduction to Vehicle Dynamics: Overview and Feedback Mechanisms, Speed Control Techniques: Point Mass Model and Force Input, Maneuvers: Stopping and Swerving - Advanced Control Systems for Vehicles, Car Following Techniques, Introduction to Advanced Cruise Control Systems - Steering Control Strategies: Point Mass Model: Open-Loop Commands for Steering Control, Point Mass Model: Closed-Loop Commands for Steering Control.

CO3: Examine various types of sensors and their integration within system architecture **L:9**

System Architecture: Hybrid System Formulation - State Machines: Challenge Events – Sensors: Proximity Sensors, Vehicle Internal State Sensing: Pressure, Temperature, GPS, Inertial Measurements, External World Sensing: Image Processing Sensors, LIDAR - Estimation and Fusion: Sensor Fusion, Track Classification - Safety Systems: Antilock-Brake Systems - Control Systems: Steering Control, Lane Following - Parking.

CO4:Employ the various algorithms and techniques utilized in mapping and path planning for autonomous electric vehicles **L:9**

Introduction to Map Databases - Principles of Path Planning - Fundamentals of Radar Tracking Systems - Vehicle-to-Vehicle Communication (V2V) Technologies - Vehicle-to-Infrastructure Communication (V2I) Systems - Panoramic Imaging Model.

CO5: Apply the principles discussed in recent research to real-world scenarios involving autonomous systems **L:9**

Exploration of Advancements in Autonomous Electric Vehicles (AUEVs) - Addressing

Global Challenges in AUEV Systems - Comparative Analysis between Autonomous Electric Vehicles and Conventional Electric Vehicles: Evaluating Benefits, Costs, Performance Metrics, and Life Cycle Considerations.

TEXT BOOKS:

1. Yu, Huafeng, Xin Li, Richard M. Murray, S. Ramesh, and Claire J. Tomlin, eds. Safe, Autonomous and Intelligent Vehicles. Springer, 2018.
2. Hanky Sjafrie, Introduction to Self-Driving Vehicle Technology (Chapman & Hall/CRC Artificial Intelligence and Robotics Series), CRC Press 2020.
3. Adouane, Lounis. Autonomous vehicle navigation: from behavioral to hybrid multicontroller architectures. CRC Press, 2016.
4. Bizon, Nicu, Lucian Dascalescu, and NaserMahdaviTabatabaei, eds. Autonomous vehicles: intelligent transport systems and smart technologies. Nova Science Publishers, 2014.

REFERENCES:

1. Nonami, Kenzo, MuljowidodoKartidjo, K. Yoon, and AgusBudiyono. "Autonomous control systems and vehicles." Intelligent Systems, Control and Automation: Science and Engineering 65 (2013).
2. Ozguner, Umit, TankutAcarman, and Keith Alan Redmill. Autonomous ground vehicles. Artech House, 2011.
3. Fazlollahtabar, Hamed, and Mohammad Saidi-Mehrabad. Autonomous guided vehicles. Vol. 20. Springer Science and Business Media LLC: Cham, Switzerland, 2015.
4. Cheng, Hong. Autonomous intelligent vehicles: theory, algorithms, and implementation. Springer Science & Business Media, 2011.

L: 45; TOTAL: 45 PERIODS

Course Code	AUTOMOTIVE ELECTRICAL AND ELECTRONICS	L	T	P	E	C
23EE02E		3	0	0	0	3

COURSE OUTCOMES

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

Theory Component:

CO1: Demonstrate and Explain the Characteristic of Batteries.
CO2: Explain the working of Electrical Components.
CO3: Demonstrate the operation of Ignition System.
CO4: Describe about Sensors and Actuators.
CO5: Describe about Wiring, Lighting and Other Instruments.

CO1: Demonstrate and Explain the Characteristic of Batteries. **L:9**

Principle and construction of Lead Acid Battery, Nickel – Cadmium Battery, Nickel Metal, Hybrid Battery, Sodium Sulphur Battery and Aluminum Air Battery, Characteristics of Battery, Battery Rating, Capacity and Efficiency, Various Tests on Battery, Battery–Charging Techniques, Maintenance of batteries.

CO2: Explain the working of Electrical Components. **L:9**

Requirements of Starter Motor, Starter Motor types, construction and characteristics, Starter drive mechanisms, Starter Switches and Solenoids, Charging system components, Generators and Alternators, types, construction and Characteristics. Voltage and Current Regulation, cut –out relays and regulators, Charging circuits for D.C. Generator, A.C. Single Phase and Three – Phase Alternators

CO3: Demonstrate the operation of Ignition System. **L:9**

Battery Coil and Magneto–Ignition System, Circuit details and Components of Battery Coil and Magneto–Ignition System, Spark Plugs, Constructional details and Types – Electronically–Assisted and Full Electronic Ignition System, Non–Contact–type Ignition Triggering devices, Capacitive Discharge Ignition Distributor–less Ignition System, Digital Ignition System, Control Strategy of Electronic Ignition System

CO4: Describe about Sensors and Actuators. **L:9**

Microcontrollers – Sensor-Signal Processing – Data Processing in the vehicle – Glossary for automotive microelectronics. Automotive Sensors – Basics – Sensors: Position, speed, Vibrational, Force, Torque, Flow meters, GasConcentration, Temperature. Automotive Actuators – Electromechanical actuators – Fluidmechanical actuators - Ratings for electrical actuators.

CO5: Describe about Wiring, Lighting and Other Instruments. **L:9**

Automotive Wiring, Insulated and Earth Return System, Positive and Negative Earth Systems, Head Lamp and Indicator Lamp Details, Anti–Dazzling and Dipper Details, Electrical and Electronic Fuel Lift Pumps, Theory and Constructional Details of Dash Board Instruments and their Sensors like Speedometer, Odometer, Fuel Level Indicator Oil Pressure and Coolant Temperature Indicators, Horns and Wiper Mechanisms, Automotive Wiring Circuits.

TEXT BOOKS:

1. Young, A.P. and Griffith, S.L., Automobile Electrical Equipments, ELBS and New Press.
2. Kholi .P.L.Automotive Electrical Equipment, Tata McGraw-Hill co ltd, New Delhi, 2004

REFERENCES:

1. Crouse.W.H. Automobile Electrical Equipment, McGraw Hill Book Co Inc.NewYork, 2005.
2. Judge.A.W.Modern Electrical Equipments of Automobiles, Chapman & Hall, London 2004.
3. Robert Bosch, Automotive Handbook, Bently Publishers,2004
4. Bosch Automotive Electrics and Automotive Electronics Systems and Components, Networking and Hybrid Drive, 5th Edition, 2007, ISBN No: 978-3-658-01783-5.

L: 45; TOTAL: 45 PERIODS

Course Code	ELECTRIC VEHICLE SAFETY	L	T	P	E	C
23EE03E		3	0	0	0	3

COURSE OUTCOMES

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

Theory Component

CO1: Identify electric vehicle hazards and outline key safety standards.

CO2: Analyse high-voltage systems and protection strategies in EVs.

CO3: Illustrate battery safety features, thermal risks, and protective systems.
CO4: Apply motor and power train safety methods including fault detection and isolation.
CO5: Perform safety testing and evaluate recent trends in EV safety technologies

CO1: Identify electric vehicle hazards and outline key safety standards. **L:9**

Need for EV safety - Types of EV hazards: electrical, chemical, thermal, mechanical – Basic safety architecture in EVs – Risk analysis methods: FMEA, FTA, HAZOP – Overview of safety regulations: ISO 26262, ASIL, AIS 156, UN R100 – Safety levels in EV design lifecycle – Sustainability relevance.

CO2: Analyse high-voltage systems and protection strategies in EVs. **L:9**

High-voltage layout and components – Electrical isolation and insulation testing - Grounding and bonding – Short-circuit and arc-flash protection – Safety during charging/discharging – Safety relays and contactors – introduction to charging standards, wireless charging and its safety implications.

CO3: Illustrate battery safety features, thermal risks, and protective systems **L:9**

Battery safety risks: overcharge, over-discharge, thermal runaway – Battery protection circuits and enclosures – Fire suppression systems – Thermal sensors and BMS role – Active and passive cooling – Cell and module-level thermal protection.

CO4: Apply motor and power train safety methods including fault detection and isolation. **L:9**

Motor safety: insulation failures, over-temperature protection, over speed limits – Functional safety in powertrain – Fault detection and emergency stop – Safety-critical signals – Redundancy in drive systems– Motor thermal sensors and cooling integration – Predictive diagnostics using AI and IoT

CO5: Perform safety testing and evaluate recent trends in EV safety technologies. **L:9**

Testing of EV components: motor, battery, powertrain – Crash and post-crash safety – High-voltage interlock loop (HVIL) – Battery recycling safety – EV testing protocols: BIS, AIS, UL, SAE – Safety in autonomous EVs – Cyber security risk in EV - Emerging AI-based safety tools and digital twins.

TEXT BOOKS:

1. James Larminie, Electric Vehicle Technology Explained, Wiley, 2022.
2. Rodrigo Garcia-Valle, Electric Vehicle Integration into Modern Power Networks, Springer, 2020.
3. Ganesan Senthilkumar, Battery Safety and Fault Detection in Electric Vehicles, CRC Press, 2023.
4. Jörg Scholz, Functional Safety for Road Vehicles, Springer, 2020.

REFERENCES:

1. SAE J2464 – Electric and Hybrid Vehicle Rechargeable Energy Storage System (RESS) Safety and Abuse Testing, 2023 (https://chargedevs.com/wp content/uploads/2023/10/SAE-J2464-RESS-Safety-Test-2023.pdf)
2. IEEE Transactions on Vehicular Technology – Special Issue on EV Safety and Risk Analysis, Vol. 72, Issue 4, April 2023(https://vtsociety.org/publication/ieee-transactions-vehicular-technology/).

3. Example article: Real-time fault detection in EV drive systems – DOI: 10.1109/TVT.2023.3256789. (https://doi.org/10.1109/TVT.2023.3256789).
4. ISO 26262: Road Vehicles – Functional Safety, 2nd Edition, 2018.(https://www.iso.org/standard/68383.html)
5. UN Regulation No. 100 – Uniform Provisions Concerning the Approval of Vehicles with Regard to Specific Requirements for the Electric Power Train, Rev. 3, 2022.(https://unece.org/sites/default/files/2025-05/R100r2am5e.pdf)
6. AIS-038 (Rev. 2): Safety Requirements of Electric Power Train Vehicles, September 2020.(https://hmr.araiindia.com/api/AISFiles/AIS_038_Rev2_Draft.pdf)
7. AIS-156: Specific Requirements for L-Category Electric Vehicles, 2019.(https://morth.nic.in/sites/default/files/ASI/AIS-156.pdf)
8. Amendments to AIS-038 and AIS-156 – Timeline and Implementation Guidelines, October 2022 & March 2023.
9. (https://morth.nic.in/sites/default/files/ASI/Press%20note_Extension%20of%20timelines_v2.pdf).

L: 45; TOTAL: 45 PERIODS

Course Code	BATTERY MANAGEMENT SYSTEMS AND MODELING	L	T	P	E	C
23EE04E		3	0	0	0	3

COURSE OUTCOMES

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

Theory Component

CO1: Describe battery types, characteristics, and their roles in electric vehicles.

CO2: Analyze battery capacity, efficiency, and thermal behavior in vehicle applications.

CO3: Illustrate the structure, sensing, and control strategies of Battery Management Systems (BMS).

CO4: Apply SoC and SoH estimation techniques in real-time EV battery systems.

CO5: Perform practical configuration, testing, and evaluation of BMS-integrated EV systems through lab experiments and research-oriented activities.

CO1: Describe battery types, characteristics, and their roles in electric vehicles **L:9**

Battery basics – Classification and types – Equivalent circuit modeling – Fuel Cell Technology – Supercapacitors – Selection of battery type for EV applications – Overview of battery chemistry: Li-ion, $LiFePO_4$, NMC – Basic charge/discharge characteristics - flash charging, rate of charging.

CO2: Analyze battery capacity, efficiency, and thermal behavior in vehicle applications **L:9**

Battery efficiency and energy balance – Traction battery pack design – VRLA and Lithium-ion battery behavior – Temperature effects on capacity and life – SoC calculation techniques – Charging/discharging dynamics – depth of discharge - Battery thermal modeling – Introduction to thermal management strategies in EVs.

CO3: Illustrate the structure, sensing, and control strategies of Battery **L:9**

Management Systems (BMS).

BMS configuration – Distributed vs centralized BMS – Sensing techniques: voltage, current, temperature – Isolation and protection strategies – Charge/discharge control – Embedded controller interface – CAN communication – wireless Battery Management Systems - Introduction to AI in BMS diagnostics and predictive maintenance.

CO4: Apply SoC and SoH estimation techniques in real-time EV battery systems. **L:9**

State of Charge (SoC) estimation: OCV method, Coulomb counting, Kalman filtering (KF, EKF) – State of Health (SoH) estimation and degradation modeling – Data-driven SoC/SoH estimation using machine learning – Battery aging phenomena – Simulation of battery behavior under real-world EV driving conditions.

CO5: Perform practical configuration, testing, and evaluation of BMS-integrated EV systems through lab experiments and research-oriented activities. **L:9**

BMS functional testing – Cell/module/pack level validation – Accelerated cycle testing – Cell balancing techniques – EV battery safety standards (ISO 26262, UN 38.3) – Fault detection and mitigation – Battery recycling and disposal – EV charging protocols – AI-based fault prediction and digital twin systems.

TEXT BOOKS:

1. Shunli Wang, Carlos Fernandez et al., Battery System Modeling, Elsevier, 2021.
2. Gregory L. Plett, Battery Management Systems, Volume I & II, Artech House, 2015.
3. H.J. Bergveld et al., Battery Management Systems: Accurate SoC Indication, Springer, 2008.
4. Davide Andrea, Battery Management Systems for Large Lithium-Ion Battery Packs, Artech House, 2010.
5. Daniel-Ioan Stroe et al., State Estimation in Lithium-ion Batteries: Algorithms and Tools, Springer, 2020.

REFERENCES:

1. Shukla Karmakar; Aashish Kumar Bohre; Tushar Kanti Bera, Recent Advancements in Cell Balancing Techniques of BMS for EVs: A Critical Review, IEEE Transactions on Industry Applications, 2025 (https://ieeexplore.ieee.org/document/10848211).
2. Jossen, Andreas, Battery Management for Portable Devices, Wiley, 2021 (https://advanced.onlinelibrary.wiley.com/doi/full/10.1002/aenm.202101126).

L: 45; TOTAL: 45 PERIODS

Course Code	ELECTRIC VEHICLE MACHINES AND DRIVES	L	T	P	E	C
23EE05E		3	0	0	0	3

COURSE OUTCOMES

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

Theory Component

CO1: Describe the types, components, and basic dynamics of electric vehicles and their drive

systems.

CO2: Analyse the operation of DC and AC motor drives used in EV propulsion.

CO3: Illustrate the working principles and control strategies of PMBLDC, PMSM, and SRM motors used in EVs.

CO4: Outline the characteristics and control of advanced electric motors used in high-performance EVs.

CO5: Apply modern tools and experimental methods to test and interface EV motors, BMS, and control units.

CO1: Describe the types, components, and basic dynamics of electric vehicles and their drive systems **L:9**

Basics of electric vehicles – Types: BEV, HEV, PHEV, FCEV – Key EV components – Drive cycle analysis – Basic vehicle dynamics – EV modeling and simulation – Comparison with IC engine vehicles – Overview of EV power train – EV trends and challenges – Battery technologies and integration overview.

CO2: Analyse the operation of DC and AC motor drives used in EV propulsion. **L:9**

Basics of DC motor drives – Modeling and control of DC motors – Speed control using converters and choppers – Introduction to induction motors – Torque-speed characteristics – Scalar control (V/f) – Vector control methods – Inverter topologies: six-step, PWM, advanced types – Efficiency analysis in motor drive applications.

CO3: Illustrate the working principles and control strategies of PMBLDC, PMSM, and SRM motors used in EVs. **L:9**

PMBLDC motor construction – Operating principle – Sensorless and sensored control – Inverter control of PMBLDC motors – PMSM modeling – Vector control of PMSM – Rotor field-oriented control – Basics of SRM – Step angle and position sensing – Converter control of SRM – Comparison and applications in two-wheeler and three-wheeler EVs.

CO4: Outline the characteristics and control of advanced electric motors used in high-performance EVs. **L:9**

Stator-PM motor drive systems – Doubly salient and hybrid PM machines – Axial flux machines – Magnetic-geared motors – Vernier PM motors – High torque-density motor designs – Inverter and vector control strategies – Real-time simulation applications – Case studies of advanced EV architectures.

CO5: Apply modern tools and experimental methods to test and interface EV motors, BMS, and control units. **L:9**

AI and ML for motor control and fault detection – Thermal management in motors – BMS configuration and integration – Embedded controllers for motor and vehicle control – Vehicle Control Unit (VCU) basics – EV testing, validation, and certification – Autonomous drive feature overview.

TEXT BOOKS:

1. Denton T., “Electric and Hybrid Vehicles”, Routledge, 1st Edition, 2020.
2. Hughes A. and Drury B., “Electric Motors and Drives”, Newnes, 4th Edition, 2019.
3. Husain I., “Electric and Hybrid Vehicles: Design Fundamentals”, CRC Press, 2nd Edition,

2021.
4. Chau K.T., "Electric Vehicle Machines and Drives", Wiley, 1st Edition, 2015.

REFERENCES:

1. Emadi A., "Advanced Electric Drive Vehicles", CRC Press, 2014.
2. Tashakor N. et al., "Modular Reconfigurable Mixed Battery System with Heterogeneous Modules", IEEE Transactions on Transportation Electrification, Vol. 10, 2024, DOI: 10.1109/TTE.2024.3362849.
3. SAE International Journal of Electrified Vehicles, Volume 14, Issue 1 (2025)
4. Goyal V. et al., "Real-Time Implementable Reduced-Order Energy Model for an Electric Vehicle", SAE Int. J. Elec. Veh., 14(1), Aug 22 2024, DOI: 10.4271/14-14-01-0006
5. EV Technical Manuals & White Papers

L: 45; TOTAL: 45 PERIODS

Course Code		L	T	P	E	C
23EE06E	**ELECTRIC VEHICLE DYNAMICS**	3	0	0	0	3

COURSE OUTCOMES

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

Theory Component

CO1: Explain the fundamentals of vehicle motion, tractive effort, and resistive forces in electric vehicles.
CO2: Analyze longitudinal, lateral, and vertical dynamics of electric vehicles using basic models.
CO3: Illustrate powertrain, tire, suspension, and steering effects on vehicle performance.
CO4: Evaluate vehicle stability, braking, and acceleration through analytical and simulation approaches.
CO5: Discuss recent trends in intelligent control, AI/ML-based EV dynamics, and digital twin simulations

CO1: Explain the fundamentals of vehicle motion, tractive effort, and resistive forces in electric vehicles. **L:9**

EV classification, architecture overview, comparison of EV and IC engine vehicles, coordinating systems, tractive effort and resistive forces, acceleration, gradient, and braking dynamics, power and energy balance equations, performance curves.

CO2: Analyze longitudinal, lateral, and vertical dynamics of electric vehicles using basic models. **L:9**

Longitudinal dynamics: acceleration, gradeability, and regenerative braking; Lateral dynamics: cornering, side-slip, yaw stability; Vertical dynamics: ride comfort, suspension stiffness, sprung and unsprung mass.

CO3: Illustrate powertrain, tire, suspension, and steering effects on vehicle performance. **L:9**

Electric powertrain components, motor torque–speed characteristics, transmission efficiency, tire modeling and traction control, suspension geometry, steering system models, vehicle roll and pitch motion.

CO4: Evaluate vehicle stability, braking, and acceleration through analytical and simulation approaches. **L:9**

Vehicle handling and stability factors, steady-state and transient cornering, braking

efficiency, load transfer, anti-lock braking system (ABS), traction control system (TCS), simulation of EV dynamics.

CO5:Discuss recent trends in intelligent control, AI/ML-based EV dynamics, and digital twin simulations **L:9**

AI/ML-assisted vehicle dynamics control, digital twin for EV performance monitoring, energy optimization, V2X and autonomous driving influence on dynamics, case studies on-EVs (Two/Three, Four Wheelers)

TEXT BOOKS:

1. Thomas D. Gillespie, Fundamentals of Vehicle Dynamics, SAE International, 2nd Edition, 2022.
2. Rajesh Rajamani, Vehicle Dynamics and Control, Springer, 3rd Edition, 2023.
3. J.Y. Wong, Theory of Ground Vehicles, Wiley, 5th Edition, 2021.

REFERENCES:

1. Hans B. Pacejka, Tire and Vehicle Dynamics, Elsevier, 4th Edition, 2020.
2. Reza N. Jazar, Vehicle Dynamics: Theory and Application, Springer, 4th Edition, 2022.
3. Iqbal Husain, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 3rd Edition, 2021.
4. Amit Jain & Avanish Tripathi, NPTEL Course: Vehicle Dynamics and Electric Motor Drives, IIT Delhi, 2023 [Online: https://nptel.ac.in/courses/108102121].
5. Vittore Cossalter, Motorcycle Dynamics, Lulu Press, 2nd Edition, 2019.
6. https://blogs.mathworks.com/student-lounge/2020/12/22/using-physical-modeling-to-design-and-simulate-an-electric-vehicle/

L: 45; TOTAL: 45 PERIODS

Course Code	CONTROL OF HYBRID ELECTRIC VEHICLE	L	T	P	E	C
23EE07E		3	0	0	0	3

COURSE OUTCOMES

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

Theory Component

CO1: Discuss the architecture, classification, and energy flow in Hybrid Electric Vehicles (HEVs).
CO2: Analyze and modeling and control strategies for power train components in HEVs.
CO3: Design and implement control techniques for energy management and drive operation.
CO4: Evaluate converter, inverter, and motor control algorithms for hybrid propulsion systems.
CO5: Apply advanced control, optimization, and AI techniques in real-time HEV systems.

CO1: Discuss the architecture, classification, and energy flow in Hybrid Electric Vehicles (HEVs). **L:9**

Introduction to hybrid and plug-in hybrid vehicles – HEV configurations: series, parallel, and series–parallel – Power-train components and energy flow – Overview of HEV subsystems: engine, motor, battery, power converters – Energy sources and regenerative braking principles – Comparative analysis of BEV, HEV, and FCEV

CO2: Analyze the modeling and control strategies for power train components in HEVs. **L:9**

Dynamic modeling of vehicle and power train – Engine and electric motor torque-speed characteristics – Transmission and gear ratio selection – Hybridization factor – Modeling of battery and super capacitor – Vehicle longitudinal dynamics – Drive cycle simulation – Introduction to vehicle modeling software (MATLAB/Simulink).

CO3: Design and implement control techniques for energy management and drive operation **L:9**

Energy management strategies: rule-based, optimization-based, and AI-based methods – Power split control between engine and motor (Simulation of HEV power split control using MATLAB/Simulink) – Control during acceleration, cruising, and regenerative braking – Supervisory control architecture – Fuzzy and neural control techniques for energy optimization.

CO4: Evaluate converter, inverter, and motor control algorithms for hybrid propulsion systems **L:9**

DC–DC converters for traction and auxiliary power – Inverter control for AC drives – Field-Oriented Control (FOC) and Direct Torque Control (DTC) of traction motors – Coordination of ICE and electric drives – Regenerative braking converter operation – Vehicle control unit (VCU) functions – Interface with Battery Management System (BMS).

CO5: Apply advanced control, optimization, and AI techniques in real-time HEV systems **L:9**

Model Predictive Control (MPC) in HEVs – Adaptive cruise control and torque blending – AI-based predictive energy management – Digital twin applications – Vehicle-to-grid (V2G) and grid-connected hybrid operation – Emerging technologies: hybrid fuel cell systems, connected HEVs, and autonomous hybrid control

TEXT BOOKS:

1. Husain, I., Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 3rd Edition, 2021.
2. Ehsani, M., Gao, Y., Gay, S.E., and Emadi, A., Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, CRC Press, 3rd Edition, 2020.
3. Chau, K.T., Electric Vehicle Machines and Drives: Design, Analysis and Application, Wiley, 2015.

REFERENCES:

1. Mi, C., Masrur, M.A., and Gao, D.W., Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, Wiley, 2nd Edition, 2022.
2. Krishnan, R., Electric Motor Drives: Modeling, Analysis, and Control, Pearson, 2017.
3. IEEE Transactions on Vehicular Technology, Special Issues on Hybrid and Electric Vehicle Control, IEEE, 2021–2024.
4. MATLAB & Simulink, Hybrid Electric Vehicle Control Tutorials, MathWorks, 2025b Version

L: 45; TOTAL: 45 PERIODS

Course Code	GRID INTEGRATION OF ELECTRIC VEHICLES	L	T	P	E	C
23EE08E		3	0	0	0	3

COURSE OUTCOMES

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

CO1: Discuss the development, integration, and applications of Vehicle-to-Grid (V2G) technology in modern power systems.

CO2: Describe the benefits of Vehicle-to-Grid (V2G) technology in improving grid efficiency and supporting sustainable energy systems.

CO3: Identify and discuss the technical and economic challenges affecting the implementation and operation of Vehicle-to-Grid (V2G) systems.

CO4: Summarize the regulatory and legal challenges influencing the deployment of Vehicle-to-Grid (V2G) systems.

CO5: Analyze M2M communication for electric vehicles, including architecture, data logging, Scalability and scheduling for efficient energy management.

CO1: Discuss the development, integration, and applications of Vehicle-to-Grid (V2G) technology in modern power systems. **L: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: Other Concepts Related to V2G.

CO2: Describe the benefits of Vehicle-to-Grid (V2G) technology in improving grid efficiency and supporting sustainable energy systems. **L: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.

CO3: Identify and discuss the technical and economic challenges affecting the implementation and operation of Vehicle-to-Grid (V2G) systems. **L:9**

Technical Challenges-Battery Degradation, Charger Efficiency, Aggregation and Communication, V2G in a Digital Society. The Economic and Business Challenges to V2G - Evaluating V2G Costs and Revenues , EV Costs and Benefits , Adding V2G Costs and Benefits , Additional V2G Costs , The Evolving Nature of V2G Costs and Benefits. Regulatory and Political Challenges to V2G, V2G and Regulatory Frameworks, Market Design Challenges.

CO4: Summarize the legal challenges influencing the deployment of Vehicle-to-Grid (V2G) systems. **L:9**

Introduction - Motor Vehicle Ownership and EV Migration - Impact of Estimated EVs on Electrical Network - Impact on Smart Grid - Standardization and Plug-and-Play - IEC 61850 Communication Standard and IEC 61850-7-420 Extension.

CO5: Examine M2M communication in EVs for scalable data logging and efficient energy scheduling. **L:9**

Introduction - Machine to Machine (M2M) in distributed energy management systems - M2Mcommunication for EVs - M2M communication architecture (3GPP) –Electric

vehicle data logging -Scalability of electric vehicles -M2M communication with scheduling.

TEXT BOOKS:

1. Emadi, A. Advanced Electric Drive Vehicles. 1st Edition, CRC Press, 2017.
2. Rajakaruna, S., Shahnia, F., & Ghosh, A. Plug-In Electric Vehicles in Smart Grids: Charging Strategies. 1st Edition, Springer, 2015.
3. Kishor, N. & Fraile-Ardanuy, J. ICT for Electric Vehicle Integration with the Smart Grid. 1st Edition, IET, 2020.
4. Lu, J. & Hossain, J. Vehicle-to-Grid: Linking Electric Vehicles to the Smart Grid. 1st Edition, IET, 2015.
5. Noel, L., Zarazua de Rubens, G., Kester, J., & Sovacool, B. K. Vehicle-to-Grid: A Sociotechnical Transition beyond Electric Mobility. 1st Edition, 2019.

REFERENCES:

1. Electric Vehicle Battery Systems, Sandeep Dhameja, Elsevier, 2012, 1st Edition.
2. Advanced Electric Drive Vehicles, Ali Emadi, CRC Press, 2017, 1st Edition.
3. Electric & Hybrid Vehicles Design Fundamentals, Iqbal Hussain, CRC Press, 2011, 2nd Edition.
4. Hybrid electric Vehicles Principles and applications with practical perspectives, Chris Mi,M. Abul Masrur, D. Wenzhong Gao, A Dearborn, John Wiley & Sons Ltd. , 2017, 2nd Edition.
5. The automobile, In Electric Vehicles: Prospects and Challenges, T. Muneer and I. Illescas García, Elsevier, 2017, 1st Edition.
6. Plug in Electric Vehicles in Smart Grids, S. Rajakaruna, F. Shahnia, and A. Ghosh, Springer Singapore, 2015, 1st Edition.
7. Vehicle-to-Grid: Linking electric vehicles to the smart grid, J. Lu, and J. Hossain, IET, 2015, 1st Edition.

L; 45 TOTAL: 45 PERIODS

Course Code	DESIGN OF POWER CONVERTERS	L	T	P	E	C
23EE09L	LABORATORY	0	0	2	0	1

COURSE OUTCOMES

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

Practical Component

CO1: Model, simulate, and analyze various power electronic converters and inverters using MATLAB/SIMULINK for different operating conditions.

CO2: Evaluate the performance characteristics, control strategies, and efficiency of power electronic systems for practical applications such as DC–DC conversion, AC–DC conversion, and motor/EV drive operations

List of Experiments:

1. Modeling of Phase controlled Rectifier using MATLAB / SIMULINK **P:30**
2. Modeling and simulation of a Buck Converter with open-loop control & Closed loop Control using MATLAB / SIMULINK.
3. Design and simulation of a Boost Converter for specified output voltage and load conditions using MATLAB / SIMULINK.
4. Modeling of a Buck–Boost Converter with continuous and discontinuous current modes using MATLAB / SIMULINK.
5. Simulation of a Single-Phase Inverter and three phase voltage source inverter using Sinusoidal PWM technique in MATLAB / Simulink platform.
6. Modelling and design of a Bidirectional DC–DC Converter for battery charging and discharging operation for E-Vehicle Operation.
7. Implementation of MATRIX Converter using MATLAB / SIMULINK
8. Modeling and design of Cyclo-Converter using MATLAB / SIMULINK

TEXT BOOKS:

1. Farzin Asadi, Simulation of Power Electronics Circuits with MATLAB/Simulink: Design, Analyze, and Prototype Power Electronics, Apress, Springer Nature, 1st Edition, 2022.
2. Narayanaswamy P.R. Iyer, Power Electronic Converters: Interactive Modelling Using Simulink, Elsevier–Academic Press, 1st Edition, 2023.
3. Venkata Dinavahi and Bin Wu, Modeling and Simulation of Power Electronic Converters Using MATLAB/Simulink, John Wiley & Sons, 2020.
4. L. Ashok Kumar, K. S. Manikandan, and R. Arulmozhiyal, Power Electronics with MATLAB, CRC Press, 1st Edition, 2018.
5. Tsun-Kong Mak, PID and Predictive Control of Electrical Drives and Power Converters Using MATLAB/Simulink, Wiley–IEEE Press, 2nd Edition, 2021.
6. MathWorks Inc., Simscape Electrical and Simulink Documentation – Power Electronics and Drives Modeling, The MathWorks, Natick, MA, Latest Release (R2024a).

P: 30; TOTAL: 30 PERIODS

Course Code	EV BATTERY DESIGN AND MODELING	L	T	P	E	C
23EE10L	LABORATORY	0	0	2	0	1

COURSE OUTCOMES

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

Practical Component

CO1: Identify and model different EV battery chemistries and parameters using experimental and simulation tools.

CO2: Analyze charge–discharge, SoC, and efficiency characteristics using real-time kits and Simulink models.

CO3: Design, simulate, and evaluate integrated BMS, powertrain, and battery system using MATLAB/Simulink.

List of Experiments:

1. Study of electric vehicle architecture and powertrain using BLDC hub-motor test setup.(CO1) **P:30**

2. Study of $LiFePO_4$ cell chemistry, structure, and electrical specifications using LFP cell analyzer kit.(CO1)
3. Measurement and plotting of charging characteristics of a single $LiFePO_4$ cell under different C-rates.(CO2)
4. Measurement and plotting of discharging characteristics and efficiency analysis of a $LiFePO_4$ cell.(CO2)
5. Design and configuration of an 8S2P (24V, 12Ah) battery pack and integration with BMS (manual & auto modes).(CO2)
6. Simulation of equivalent circuit models of Li-ion and LFP batteries (Rint, Thevenin, PNGV models) using MATLAB/Simulink.(CO1)
7. Simulation and validation of charging–discharging cycles with SOC & SOH estimation using MATLAB Simscape.(CO2)
8. Experimental analysis of charging/discharging of 8S2P 24V, 12Ah battery pack through BMS interface and data logging.(CO2)
9. Battery Thermal Management System (BTMS) modeling and temperature profile analysis using MATLAB Simulink.(CO3)
10. Integration of battery model with BLDC motor (EV powertrain) to analyze current, torque, and SoC variations.(CO3)
11. Regenerative braking analysis and SoC recovery simulation using MATLAB/Simulink and EV test bench verification.(CO3)
12. Mini Project: Design and simulation of a complete EV battery subsystem - SoC/SOH estimation, fault detection, or performance comparison.(CO3)

TEXTBOOKS:

1. M. Arshad and F. A. Mohamed, Battery Management Systems and Battery Modelling using MATLAB/Simulink, Springer, 2023.
2. Iqbal Husain, Electric and Hybrid Vehicles: Design Fundamentals, 3rd edition, CRC Press, 2021.
3. Mehrdad Ehsani et al., Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, CRC Press, 3rd Edition, 2020.

REFERENCES:

1. R.Rajashekara, Advances in Electric Vehicle Battery: Modeling, Design and Applications, Wiley, 2023.
2. J. Remmlinger, Battery State Estimation: Theory and Applications, Springer, 2022.
3. MATLAB Documentation: Battery Modeling and Management in Simscape Electrical, MathWorks, 2024.
4. NPTEL Course – Battery Management Systems and EV Modeling, IIT Madras, 2023.

P: 30; TOTAL: 30 PERIODS

Course Code	ELECTRIC VEHICLES SIMULATION	L	T	P	E	C
23EE11L	LABORATORY	0	0	2	0	1

COURSE OUTCOMES

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

Practical Component

CO1: Explain the modeling and simulation principles of electric vehicle components.
CO2: Analyze the performance characteristics of battery, motor, converter, and powertrain subsystems through simulation-based studies.
CO3: Develop and evaluate integrated electric vehicle simulation models for energy flow, regenerative braking, and dynamic performance.

List of Experiments:

1. Demonstration of Electric Vehicle Architecture and Powertrain Components. (CO1) **P:30**
2. Simulation-Based Performance Evaluation of Electric Two-Wheeler Powertrain Parameters.(CO1)
3. Simulation of Dynamic behavior of Electric Three/Four-Wheeler. (CO1)
4. Modeling of Li-ion / LFP Battery Equivalent Circuit Models.(CO1)
5. Performance Analysis of BLDC Hub-Motor Drive for Electric Two-Wheelers.(CO2)
6. Simulation of EV Battery Charging and Discharging Characteristics.(CO2)
7. Modelling of DC Motor and BLDC Motor for EV Propulsion.(CO2)
8. Performance characteristics of DC–DC Converter for Electric Vehicle Drivetrain.(CO2)
9. Simulation of Regenerative Braking and Energy Recovery in Electric Vehicles.(CO3)
10. Vehicle Longitudinal Dynamics Simulation.(CO3)
11. Simulation of Integrated Electric Vehicle Powertrain (CO3)
12. Mini Project: EV range estimator / BLDC motor controller design / EV powertrain efficiency comparison / Two-wheeler EV model with drive cycle and SoC estimation.

P: 30; TOTAL: 30 PERIODS

Course Code		L	T	P	E	C
23EE12L	**AUTONOMOUS VEHICLE SENSORS**	1	0	0	0	1

COURSE OUTCOMES

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

Theory Component

CO1: Summarize the functions and applications of autonomous vehicle sensors.
CO2: Describe the role of sensor fusion & interfacing in autonomous vehicle systems.

CO1: Summarize the functions and applications of autonomous vehicle sensors **L:7**

Overview of autonomous vehicle –Architecture –autonomy levels–sensor characteristics, range, calibration and resolution–Sensors: Cameras, LiDAR, Radar, Ultrasonic, Global Navigation Satellite System (GNSS)and Inertial Measurement Unit (IMU) –Robot Operating System (ROS) Precise calibration techniques Time synchronization of sensor data streams–benefits and limitation of sensors –safety and redundancy in measurement – User data visualization.

CO2: Describe the role of sensor fusion & interfacing in autonomous vehicle systems. **L:8**

Need for Multi-Sensor Fusion: combining LiDAR's precise range with camera's semantic classification–Fusion Algorithms: Bayesian estimation, Kalman Filter and Particle Filters–Tracking and Mapping: Simultaneous Localization and Mapping

(SLAM) and Interacting Multiple Model (IMM) –Sensor Interfacing: CAN-FD, and Automotive Ethernet (IEEE 802.3bp) - ROS/ROS2 Integration: velodyne driver– Performance and Safety.

TEXT BOOKS:

1. Sebastian Thrun, Wolfram Burgard, Dieter Fox — Probabilistic Robotics, MIT Press; 1st ed., 2005.
2. Robert Bosch GmbH, Automotive Sensors and Actuators, 1st Edition, Robert Bosch GmbH, 2002.
3. Tom Denton, Automobile Electrical and Electronic Systems, 5th Edition, CRC Press/Routledge, 2017.
4. Pinliang Dong & Qi Chen (eds.) — LiDAR Remote Sensing and Applications, CRC Press (Taylor & Francis), 1st Edition, 2017.
5. S. Ramalingam, Fundamentals of Autonomous Vehicles, — Edition and Publication details not available.

REFERENCES:

1. Shaoshan Liu et al., Creating Autonomous Vehicle Systems, 2nd Edition, Morgan & Claypool Publishers, 2020.
2. D. Patranabis, Sensors and Transducers, 2nd Edition, PHI Learning, 2009.
3. Yaakov Bar-Shalom, X.-Rong Li, T. Kirubarajan — Estimation with Applications to Tracking and Navigation: Theory, Algorithms and Software, Wiley, 2001/2002.
4. Autonomous Driving and Advanced Driver- Assistance Systems (ADAS): Applications, Development, Legal Issues, and Testing: 1st Edition, Wiley.
5. Richard Hartley & Andrew Zisserman — Multiple View Geometry in Computer Vision, 2nd Edition, Cambridge University Press, 2003 (2nd ed. pub. c.2003/2004).

L: 15; TOTAL: 15 PERIODS

Course Code	INSULATION TECHNOLOGY	L	T	P	E	C
23EE09E		3	0	0	0	3

COURSE OUTCOMES

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

Theory Component

CO1: summarize the different types of insulation materials and its properties.
CO2: analyze the fundamental behavior of dielectrics in static and alternating field.
CO3: Understand the limitations of insulation design and electric field analysis
CO4: Apply computational techniques to analyze electric fields and insulation design in high voltage apparatus.
CO5: select the suitable insulation for HV power equipment and estimate its lifetime

CO1: summarize the different types of insulation materials and its properties. **L:9**

Types of dielectrics and electrical insulation systems – properties of dielectric materials -gaseous, vacuum, liquid, solid and composite insulation – polymers as dielectrics - polymer structure and morphology - classification of polymers - Cryogenic insulation-Biodegradable oils -Introduction to nano dielectrics – insulation degradation

CO2: analyze the fundamental behavior of dielectrics in static and alternating field. **L:9**

Static dielectric constant – atomic interpretation of the dielectric constant of mono-atomic gases –dependence of permittivity on various factors - polarization – Clausius-Mossotti equation – types - internal field in solids and liquids – Frequency dependence of the polarization – complex dielectric constant of non-dipolar solids – dipolar relaxation – dielectric losses.

CO3: Understand the limitations of insulation design and electric field analysis **L:9**

Conventional Insulation Design Procedures and their Limitations - Need for Field Analysis based Insulation Design - Stress Distribution and Control in Insulation Systems - Electric Field effects in HV Apparatus Insulation - Partial Discharges and Field Enhancement Effects- Dynamic Electric Field Analysis under Transient and Impulse Conditions in HV Insulation Systems

CO4: Apply computational techniques to analyze electric fields and insulation design in high voltage apparatus. **L:9**

Introduction to Computational Techniques: Finite Difference Method (FDM), Finite Element Method (FEM), Charge Simulation Method - Voltage and Field Evaluation Using FDM and FEM - Elements of CAD Systems for Electromagnetic Field Analysis - Modeling, Meshing, and Boundary Conditions in CAD Software - Case Studies: Capacitance Calculation, Optimization of Insulation Geometry in High Voltage apparatus.

CO5: select the suitable insulation for HV power equipment and estimate its lifetime **L:9**

Life estimation- thermal modelling- DP/Furan/DGA Results and Application of insulating materials in power equipment and recent advancements-environment friendly and recyclable insulation- sustainability relevance.

TEXT BOOKS:

1. Adrinaus, Dekker J., “Electrical Engineering Materials”, Prentice Hall of India Pvt. Ltd., New Delhi, 2015.
2. Alston L.L, “High Voltage Technology”, Oxford University Press, London, 1968 (B.S. Publications, First Indian Edition, 2008, Reprint 2020).

REFERENCES:

1. Kuffel E., Zaengl W.S. and Kuffel J., “High Voltage Engineering Fundamentals”, Elsevier India Pvt. Ltd, 2008.
2. Dieter Kind and Hermann Karner, “High Voltage Insulation Technology”, (Translated from German by Narayana Rao Y., Friedr. Vieweg & Sohn, Braunschweig), 1985.
3. Naidu M.S. and Kamaraju V., “High Voltage Engineering”, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2020.
4. Ushakov V.Y., “Insulation of High Voltage Equipment”, Springer, 2004.
5. Rao S. and Rao S.V., “Electromagnetic Field Theory and Transmission Lines”, McGraw-Hill Education, 3rd Edition, 2018.
6. Kalluri D.K., “Advanced Electromagnetic Computation”, CRC Press, 2nd Edition, 2018.
7. Sadiku M.N.O., “Elements of Electromagnetics”, Oxford University Press, 7th Edition,

2020.

L: 45; TOTAL: 45 PERIODS

Course Code	SUSTAINABLE AND ENVIRONMENTAL	L	T	P	E	C
23EE10E	FRIENDLY HV INSULATION SYSTEM	3	0	0	0	3

COURSE OUTCOMES

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

Theory Component

CO1: explain the sustainable and environmental energy and products.
CO2: infer the characteristics of alternate green gaseous insulators.
CO3: illustrate the characteristics of alternate green liquid insulators
CO4: Describe the characteristics of alternate green solid insulators
CO5: identify the standards for Green insulation systems

CO1: explain the sustainable and environmental energy and products. **L:9**

Carbon print, global warming potential, environment requirement for any product and system

CO2: infer the characteristics of alternate green gaseous insulators. **L:9**

SF6gas and its hazardous environmental effects, alternate gases, gaseous mixtures and other sources and its properties. Green Nano dielectric materials as insulation, Green Insulation Properties

CO3: illustrate the characteristics of alternate green liquid insulators **L:9**

Hazardous effects of existing liquid dielectric materials (such as organic oil),alternate sources of environmental friendly liquid such as natural ester oil, vegetable oils dielectric and its properties -Green nano fluid insulation, Impact of nano particles

CO4: Describe the characteristics of alternate green solid insulators

Hazardous effects of existing solid dielectric materials, alternate sources of environmental friendly solid dielectric and its properties **L:9**

CO5: identify the standards for Green insulation systems. **L:9**

Requirements, evolving standards of management, testing, usage and disposal of alternate insulation systems, Major applications and standards

REFERENCES:

1. https://www.iso.org/standard/79064.html
2. https://www.ictfootprint.eu/en/iec-tr-627252013-factsheet
3. https://www.iec.ch/dyn/www/f?p=103:7:0::::FSP_ORG_ID,FSP_LANG_ID:1275,25
4. https://www.iec.ch/ords/f?p=103:41:628762356646470::::FSP_ORG_ID,FSP_LANG_ID:3237, 25
5. https://www.iec.ch/dyn/www/f?p=103:7:0::::FSP_ORG_ID,FSP_LANG_ID:1299,25
6. https://www.iec.ch/sdgs/sdg13
7. http://high performance insulation.eu/wp-content/uploads/2016/08/sustainability_a_guide.pdf

L: 45; TOTAL: 45 PERIODS

Course Code	EHV POWER TRANSMISSION	L	T	P	E	C
23EE11E		3	0	0	0	3

COURSE OUTCOMES

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

Theory Component:

CO 1: infer the need of EHV Transmission and its design parameters.

CO 2: estimate the line parameters for multi-conductor lines.

CO 3: interpret the voltage gradients and interference issues of conductors.

CO 4: illustrate the functional requirements of earthing.

CO 5: identify the effect of electrostatic field on humans and vehicles.

CO1: infer the need of EHV Transmission and its design parameters. **L:9**

Overview of Electrical power transmission at high voltages, Standard transmission voltages - Recent advances in EHV power transmission systems; present status and future growth - Major Components of EHV transmission systems, types of conductor configurations conductor accessories/clamps - Towers for UHV transmission- right of way (ROW).

CO2: estimate the line parameters for multi-conductor lines. **L:9**

Calculation of resistance, inductance, and capacitance for multiconductor lines – Calculation of sequence inductances and capacitances – Bundled conductors -Line parameters for different modes of propagation - Resistance and inductance of ground return

CO3: interpret the voltage gradients and interference issues of conductors. **L:9**

Surface voltage gradient on conductors – gradient factors and their use – voltage gradients on conductors in the presence of ground wires on towers- Corona: Power loss due to corona, Radio noise and Audible noise and their measurement- Power handling capacities and line losses.

CO4: illustrate the functional requirements of earthing.

Substation grounding and Shielding Functional Requirements of Earthing System, Equipment Earthing, Neutral Point Earthing, Substation Earthing System, Dimensioning of Earth Conductors, Step Potential and Touch Potential, Earth Mat, Resistance of Earthing System, Values of Soil Resistivity, Fencing, Procedure of Laying Earthing, Shielding by wires and masts. **L:9**

CO5: identify the effect of electrostatic field on humans and vehicles. **L:9**

Effect of EHV line on heavy vehicles – Calculation of electrostatic field of AC lines – Effect of high field on humans, animals, and plants – Electrostatic induction in unenergized circuit of a DC line – Induced voltages in insulated ground wires.

TEXT BOOKS:

1. Rakosh Das Begamudre, “Extra High Voltage AC Transmission Engineering”, New Age International Pvt. Ltd., 5th Edition, 2023.
2. E Kuffel, W S Zaengl and J Kuffel, “High Voltage Engg. Fundamentals”, textbook published by Newness publishers, 2nd Edition, 2000.

REFERENCES:

1. CIGRE Working Group SC B.3-22, “Technical requirements for substations exceeding 800

kV", Brochure No: 400, Dec 2009.
2. IEC-60826, International standard, "Design criteria of overhead transmission lines", 2003.
3. Power Engineer's Handbook, TNEB Engineers Association, Revised and Enlarged 6th Edition, October 2002.
4. Microtran Power System Analysis Corporation, Microtran Reference Manual, Vancouver Canada. (Website: www.microtran.com)

L: 45; TOTAL: 45 PERIODS

Course Code	HVDC TRANSMISSION SYSTEMS	L	T	P	E	C
23EE12E		3	0	0	0	3

COURSE OUTCOMES

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

Theory Component

CO1: Demonstrate the knowledge of different types of HVDC transmission system
CO2: Discuss the operation of HVDC converters
CO3: Analyze the Control of HVDC Converter Systems
CO4: Apply the HVDC and AC filters to eliminate the harmonics
CO5: Assess overvoltages in HVDC systems and demonstrate protection methods

CO1:Demonstrate the knowledge of different types of HVDC transmission system **L:9**

Introduction to HVDC transmission, Comparison between HVAC and HVDC systems - Economic, technical and reliability, limitations, Types of HVDC links - Monopolar, bipolar and homopolar links - Voltage Source Converter (VSC) and Multi-terminal HVDC systems- Components of HVDC transmission system - Typical HVDC system in India- International and National Standards and regulations – Sustainability of HVDC.

CO2: Discuss the operation of HVDC converters **L:9**

Rectifier and Inverter operation of Graetz circuit without and with overlap - Output voltage waveforms and DC voltage in both rectifier and inverter operation - Equivalent circuit of HVDC link.

CO3: Analyze the Control of HVDC Converter Systems **L:9**

Control of HVDC Converter Systems Control of HVDC Converter Systems: Principle of DC link control – Constant current, Constant extinction angle and constant ignition angle control and voltage dependent current control. Individual phase control and equidistant firing angle control

CO4: Apply the HVDC and AC filters to eliminate the harmonics **L:9**

Harmonics and Filters Origin of harmonics in HVDC systems, Classification of harmonics, Elimination of harmonics, Suppression methods, Harmonic instability problems, Design of HVDC and AC filters.

CO5: Assess Overvoltages in HVDC systems and demonstrate protection methods. **L:9**

Transients, Faults and Protection of HVDC Systems Origin of over voltages in HVDC systems, Over voltages due to DC and AC side line faults – Converter faults, Over current protection – Valve group and DC line protection - Over voltage protection of converters, Surge arresters.

TEXT BOOKS:

1. Padiyar, K.R., "HVDC transmission systems", Wiley Eastern Ltd., 2024.
2. Arrilaga, J., "High Voltage Direct Current Transmission", 2nd Edition, Institution of Engineering and Technology, London, 2013.

REFERENCES:

1. Kimbark E.W., "Direct Current Transmission – Vol. 1", Wiley Interscience, 1st Edition, 1971.
2. Kamakshaiah S. and Kamaraju V., "HVDC Transmission", McGraw Hill Education (India), 2nd Edition, 2020.
3. Sood V.K., "HVDC and FACTS Controllers: Applications of Static Converters in Power Systems", Springer, 1st Edition, 2004.

L: 45; TOTAL: 45 PERIODS

Course Code	HIGH VOLTAGE SWITCHGEAR	L	T	P	E	C
23EE13E		3	0	0	0	3

COURSE OUTCOMES

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

Theory Component

CO1: Describe the insulation clearance requirements for external and internal high-voltage installations.
CO2: Explain the arc-interruption mechanisms employed in high-voltage circuit breakers.
CO3: Summarize the design principles involved in air circuit breakers used in high-voltage systems.
CO4: Discuss modern design trends and technologies adopted in oil-less circuit breakers.
CO5: Outline the functional characteristics of SF_6 and vacuum circuit breakers for reliable high-voltage operation.

CO1: Describe the insulation clearance requirements for external and internal high-voltage installations. **L:9**

Insulation of switchgear - coordination between inner and external insulation, Insulation clearances in air, oil, SF6 and vacuum, bushing insulation, solid insulating materials – IEC 62271 - dielectric and mechanical strength consideration – Isolating, earthing and load switches.

CO2: Explain the arc-interruption mechanisms employed in high-voltage circuit breakers. **L:9**

Switchgear terminology – Arc characteristics – direct and alternating current interruption – mathematical modeling of arc – dielectric strength recovery – computer simulation of arc models – transient re-striking voltage – RRRV-recovery voltage-current chopping-IEC 62271-110,313 - capacitive current breaking-auto re-closing.

CO3: Summarize the design principles involved in air circuit breakers used in high-voltage systems. **L:9**

General Layout – Electric Arc Behavior in a Longitudinal Flow of Compressed Air – Thermodynamic Clogging of the Blast Nozzle, Nozzle Section Vs Breaking Current Relation – Recovery of Dielectric Strength in Axial Blast Interrupters – Aiding Arc Extinction with Shunt Resistors and Capacitors.

CO4: Discuss modern design trends and technologies adopted in oil-less circuit breakers. **L:9**

Layout of Bulk and Low-Oil Breakers – Construction and Operation of Interrupters – Extinction Chamber Pressure Analysis – Auto-Reclosing Duty and Frequent Make-Break Operations – Operating Mechanisms – Driving and Tripping Mechanisms – Trends in the Development of Oil Less Circuit Breakers – Breaker Design – Autonomous Switchgear and Intelligent Operating Systems - Case studies.

CO5: Outline the functional characteristics of SF_6 and vacuum circuit breakers for reliable high-voltage operation. **L:9**

Insulating and Interrupting Properties of SF6 –Analysis and Construction of SF6 Circuit Breakers – IEC 60376 , 60480 - Vacuum circuit breakers: Status and trends in continuous current and interrupting ratings – IEC 62271-100 - Mechanical and thermal withstand capabilities– Construction and layout – Breaker design

TEXT BOOKS:

1. Kunio Nakanishi, "Switching Phenomena in High Voltage Circuit Breakers", Marcel Dekker Inc., New York, 1991.
2. Kuffel, E., Zaengl, W.S. and Kuffel J., "High Voltage Engineering Fundamentals", Elsvier India Pvt. Ltd, 2008

REFERENCES:

1. Chunikhin, A. and Zhavoronkov, M., "High Voltage Switchgear Analysis and Design", Mir Publishers, Moscow, 1989.
2. Flursscheim, C.H. (Editor), "Power Circuit Breaker-Theory and Design", IEE Monograph Series 17, Peter Peregrinus Ltd., Southgate House, Stevenage, Herts, SC1 1HQ, England, 1977.
3. Ananthakrishnan S and Guruprasad K.P., "Transient Recovery Voltage and Circuit Breakers", Tata McGraw-Hill Publishing Company Ltd., New Delhi, 1999.
4. IEC 62271-100 (Ed 1.1), "High-voltage switchgear and control gear – Part 100: High-voltage alternating-current circuit-breakers" Annex E
5. Working Group 13.CC.03, "Transient recovery voltages in medium voltage networks", CIGRE 134.
6. CIGRE Green Book, & "Switching Equipment", Study Committee A3: High Voltage Equipment, PP 83 -155, 2018

L: 45; TOTAL: 45 PERIODS

Course Code	CONDITION MONITORING OF HIGH VOLTAGE POWER EQUIPMENT	L	T	P	E	C
23EE14E		3	0	0	0	3

COURSE OUTCOMES

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

Theory Component

CO1: Identify substation equipment and apply basic condition monitoring techniques using key insulation diagnostic parameters.

CO2: Analyze insulation ageing, failure modes, and the impact of partial discharges in condition assessment

CO3: Examine the condition monitoring of transformers and identify factors leading to degradation.
CO4: Apply suitable condition monitoring and diagnostic methods for rotating electrical machines.
CO5: Utilize AI techniques for Condition Monitoring of high voltage apparatus

CO1: Identify substation equipment and apply basic condition monitoring techniques using key insulation diagnostic parameters. **L:9**

Introduction to Condition Monitoring and Diagnostics Engineering Management-Techniques Employed in Condition Monitoring-Identification and Categorization of Substation Equipment-Overview of Insulation Characterization Parameters-Permittivity & Capacitance- Resistance & Insulation Resistance- Time Constants-Dielectric Dissipation Factor - Sustainability relevance – Equipment lifetime.

CO2: Analyze insulation ageing, failure modes, and the impact of partial discharges in condition assessment **L:9**

Partial Discharge: Definition, Sources, IEC standard - Effects- Physical and Chemical Changes in Insulation - Modes of Deterioration and Failure of Insulating Materials-Dielectric Losses and Ageing Effects - Damage Due to Electrical, thermal Stress and Partial Discharge - Requirements and Concepts in Insulation Design

CO3: Examine the condition monitoring of transformers and identify factors leading to degradation. **L:9**

Introduction to Transformer oil and its Functions- Causes of Oil Ageing and Accelerators- Strategies for Controlling Ageing Rate- Transformer Oil Testing and Interpretation- Power Factor, Moisture Content- Neutralization Number, Interfacial Tension- BDV, Color, Visual Inspection- DGA (Dissolved Gas Analysis), Furanic Compounds

CO4: Apply suitable condition monitoring and diagnostic methods for rotating electrical machines. **L:9**

Introduction to Monitoring of Motors and Generators- Common Causes of Electric Motor Failures - Preventive Maintenance Techniques - Monitoring Methods - Current Monitoring - Temperature Monitoring - Resistance Measurements - Lubrication and Cleaning - General Visual Inspection -Vibration Analysis

CO5: Utilize AI techniques for Condition Monitoring of high voltage apparatus **L:9**

Role of AI in Predictive Maintenance and Asset Management - Machine Learning Algorithms for Condition Monitoring of HV equipments - Applications in Transformer Fault Diagnosis using DGA Analysis - AI Techniques for Partial Discharge Pattern Recognition in rotating machines (Qualitative treatment).

TEXT BOOKS:

1. James and Q Su, "Condition Assessment of High Voltage Insulation in Power System Equipment", IET Power and Energy series, Vol. 53, 2008.
2. Sivaji Chakrovorti, Debangshu Dey, Biswendu Chatterjee, "Recent trends in the condition monitoring of transformers", Springer-Verlag, London 2013

REFERENCES:

1. Peter Tavner, Li Ran, Jim Penman and Howard Sedding, "Condition monitoring of rotating electrical machines', IET Power and Energy series, Vol. 56, 2020
2. Issouf Fofana, "Power Transformer Diagnostics, Monitoring and Design Features", Energies,

2018
3. Ahmed Abu-Siada, "Power Transformer Condition Monitoring and Diagnosis", Institution of Engineering and Technology", 2018
4. Stone, "Electrical Insulation For Rotating Machines Design, Evaluation, Aging, Testing, and Repair", IEEE Press, 2014
5. IEEE62, 62-2017 - IEEE Guide for Diagnostic Field Testing of Electric Power Apparatus - Part 1: Oil Filled Power Transformers, Regulators, and Reactors
6. IEC 60599 – 2022 - Interpretation of the analysis of gases in transformers and oil filled equipment in service
7. CIGRE TB No 462, Obtaining Value from On-Line Substation Condition Monitoring

L: 45; TOTAL: 45 PERIODS

Course Code	INSULATION COORDINATION	L	T	P	E	C
23EE13L		1	0	0	0	1

COURSE OUTCOMES

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

Theory Component

CO1: Explain the principles of insulation coordination and its importance in reliable power system operation.

CO2: Analyze overvoltage conditions and determine suitable insulation levels for various power apparatus.

CO1: Explain the principles of insulation coordination and its importance in reliable power system operation. **L:7**

Introduction to insulation coordination – concept, need, objectives, and its role in ensuring reliable system operation – internal and external overvoltages and their qualitative impact on insulation – functions of protective devices such as surge arresters, shielding, and insulation grading – overview of IEC/IEEE standards and basic testing practices related to insulation coordination.

CO2: Analyze overvoltage conditions and determine suitable insulation levels for various power apparatus. **L:8**

Assessment of overvoltage conditions and waveform characteristics – determination of insulation levels including BIL, CFO, and withstand voltages with appropriate safety margins – evaluation of insulation strength for transformers, lines, switchgear, and GIS – coordination with surge arrester ratings – application of insulation grading methods and IEC/IEEE test procedures for selecting suitable insulation levels.

TEXT BOOKS:

1. M. S. Naidu and V. Kamaraju, High Voltage Engineering, McGraw Hill Education, 6th Edition, 2022.
2. Ravindra Arora and Wolfgang Mosch, High Voltage and Electrical Insulation Engineering, Wiley India, 2011.

REFERENCES:

1. L. L. Alston, High Voltage Technology, Oxford University Press, 2007.
2. Klaus Ragaller, Surges in High Voltage Networks, Butterworth-Heinemann, 1980.

3. R. Bartnikas, Electrical Insulation for Rotating Machines: Design, Evaluation, Aging, Testing, and Repair, IEEE Press, 2018.
4. IEC 60071 – Insulation Coordination Standards, International Electrotechnical Commission, Geneva.

Course Code	ALTERNATE INSULATING MEDIUM	L	T	P	E	C
23EE14L		1	0	0	0	1

COURSE OUTCOMES

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

Theory Component

CO1: Describe the need for developing alternate insulating media in power systems.

CO2: Compare the dielectric and thermal properties of conventional and eco-friendly insulating.

CO1: Describe the need for developing alternate insulating media in power systems. **L:7**

Conventional insulating media – properties, applications, and limitations – environmental and operational challenges of traditional insulators, including ageing, toxicity, and greenhouse effects – motivation for transitioning to alternate liquid, gaseous, and solid insulating materials in modern power systems.

CO2: Compare the dielectric and thermal properties of conventional and eco-friendly insulating materials. **L:8**

Alternate insulating media such as natural and synthetic esters, nanofluids, silicone oils, vacuum, CO_2 , fluoronitrile mixtures, and polymeric dielectrics – comparative evaluation of dielectric strength, viscosity, thermal and ageing behaviour – assessment of environmental sustainability and performance differences between conventional and eco-friendly insulating materials.

TEXT BOOKS:

1. R. Bartnikas and K. D. Srivastava, Power and Communication Cables: Theory and Applications, IEEE Press, 2000.
2. Cavallini and G. C. Montanari, Advanced Dielectric Materials and Their Applications, Wiley, 2013.

REFERENCES:

1. T. K. Saha (Ed.), *Electrical Insulation Performance and Ageing: Assessment and New Technologies*, Springer, 2017.
2. B. N. Tripathi and M. K. Sharma, *Recent Trends in Alternative Insulating Fluids for Power Transformers*, CRC Press, 2020.
3. IEEE Transactions on Dielectrics and Electrical Insulation – *Special Issues on Nanofluids, Ester Oils, and SF_6 Alternatives.*
4. CIGRÉ Technical Brochure No. 436, *Natural and Synthetic Ester Liquids for Transformers*, 2010.

L: 15; TOTAL: 15 PERIODS

Course Code	HIGH VOLTAGE TESTING TECHNIQUES	L	T	P	E	C
23EE15L		0	0	2	0	1

COURSE OUTCOMES

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

Practical Component

CO1: perform the high voltage testing in insulating materials.
CO2: predict the behavior of different insulating material used in high voltage equipment.

List of Experiments:

1. Study of high voltage testing objectives, classification, standards and specifications, correction factors.
2. Measurement of AC, DC and impulse breakdown voltage of insulating material.
3. Partial discharge measurement with φ-q-n pattern.
4. Measurement of flashover voltage for dry and wet 11kV outdoor insulator.
5. Measurement of soil resistivity.
6. Measurement of 50% critical impulse flashover voltages on the 11 kV insulator for positive / negative voltages.
7. Measurement of dielectric characteristics (Insulation Resistance, Absorption Index and Polarization Index) of insulating material.
8. Investigate the effect of ESDD on critical flashover voltage of 11 kV insulator.
9. Analyse the effect of dry band location of 11 kV insulator on electric field distribution.
10. Study on measurement of Radio interference voltage.
11. Statistical Evaluation of Measured Results of breakdown phenomenon.
    i. Direct determination of probability values on disruptive discharge voltage.
    ii. Determination of the distribution function of a measured quantity.
    iii. Determination of the confidence limits of the mean value of the breakdown discharge voltage.
    iv. Determination of breakdown discharge voltages for given probability ranges.
12. Study of multi stress ageing and life time analysis for different insulating medium.

P: 30; TOTAL: 30 PERIODS

Course Code	ENERGY STORAGE SYSTEMS AND APPLICATION	L	T	P	E	C
23EE15E		3	0	0	0	3

COURSE OUTCOMES

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

Theory Component

CO1: Analyze the characteristics of energy from various sources and need for storage
CO2: Evaluate the performance of different thermal storage system
CO3: Examine the performance of fuel cell storage system
CO4: Analyze the technical aspects of battery storage system
CO5: Select suitable alternate energy storage technology for real world applications

CO1: Analyze the characteristics of energy from various sources and need for storage **L:9**

Necessity of energy storage, different types of energy storage, mechanical, chemical, electrical, electrochemical, biological, magnetic, electromagnetic, thermal, comparison of energy storage technologies

CO2: Evaluate the performance of different thermal storage system

Thermal Energy storage - Types – Modelling of thermal storage units – Energy and

exergy analysis of thermal energy storage – Mechanical: Pumped hydro, flywheels and pressurized water storage system – Simple water and rock bed storage system - Modeling of phase change storage system – Simple units, packed bed storage units **L:9**

CO3: Examine the performance of fuel cell storage system **L:9**

Electro Chemical Storage - Hydrogen production and storage, Direct energy conversion using fuel cells, Types of fuel cells, Fuel cell performance, Electrochemical Energy Storage Battery, primary, secondary and flow batteries - battery recycling.

CO4: Analyze the technical aspects of battery storage system **L:9**

Electrical Energy Storage (EES) - super-capacitors, Double-layer capacitors (DLC), Magnetic Energy storage, Superconducting systems, Superconducting magnetic energy storage (SMES), super charging stations, Standards for EES, Technical comparison of EES technologies.

CO5: Select suitable alternate energy storage technology for real world application **L:9**

Renewable energy storage - Battery sizing and stand-alone applications, stationary (Power Grid application), Smart Grid, Smart Micro grid, Small scale application-Portable storage systems, Smart House, Mobile storage Applications - Electric vehicles (EVs), types of EVs - Aggregating EES systems and distributed generation (Virtual Power Plant) - Management and control hierarchy of storage systems, future technologies, hybrid systems for energy storage.

TEXT BOOKS:

1. "James M. Eyer, Joseph J. Iannucci and Garth P. Corey ", "Energy Storage Benefits and Market Analysis", Sandia National Laboratories, 2004.
2. Ahmed Faheem Zobaa, "Energy Storage – Technologies and Applications", InTech 2013.
3. Energy Storage: Fundamentals, Materials and Applications — Robert A. Huggins, Springer, 2nd ed. 2016.
4. J. Jensen and B. Sørenson, "Fundamentals of Energy Storage," Wiley-Interscience, New York, 1984.

REFERENCES:

1. G. Pistoia, "Electric & Hybrid Vehicles: Power Sources, Models, Sustainability, Infrastructure and the Market", Elsevier B.V**.,** 2016**.**
2. R. O'Hayre, S. Cha, W. Colella & F. B. Prinz, "Fuel Cell Fundamentals", John Wiley & Sons (3rd ed.), 2016.
3. James Larminie and Andrew Dicks, "Fuel cell systems Explained", Wiley publications, 2003.
4. Ru-shiliu, Leizhang and Xueliang sun, "Electrochemical technologies for energy storage and conversion", Wiley publications, 2012.
5. Schmidt.F.W and Willmott.A.J, Thermal Storage and Regeneration, Hemisphere Publishing Corporation, 1981.
6. Ibrahim Dincer and Mark A. Rosen, "Thermal Energy Storage Systems and Applications", John Wiley & Sons 2002.

L: 45; TOTAL: 45 PERIODS

Course Code	THERMAL MANAGEMENT FOR ELECTRICAL	L	T	P	E	C
23EE16E	AND ELECTRONICS ENGINEERING	3	0	0	0	3

COURSE OUTCOMES

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

Theory Component

CO1: Implement principles of conduction, convection, and radiation to evaluate thermal performance in electronic devices

CO2: Explain Conduction, Convection and Radiation Heat Transfer in Electronic Equipment

CO3: Apply appropriate single-phase and two-phase cooling techniques to manage the thermal performance of electronic and power-electronic systems

CO4: Analyze and apply thermal-management techniques in electrical and electronic systems

CO5: Demonstrate temperature-measurement techniques and the use of thermal-simulation tools.

CO1: Implement principles of conduction, convection, and radiation to evaluate thermal performance in electronic devices **L:9**

Introduction to the Modes of Heat Transfer in Electronic Equipment – Convection, Conduction, Radiation, Practical Thermal Resistances- thermal impedance. Heat Generation in Active Devices - CMOS Devices, Junction FET, IGBT, Power MOSFET. Heat Generated in Passive Devices -Interconnects, Resistors, Capacitors, Inductors and Transformers - Thermal analysis comparison of silicon and silicon carbide devices

CO2: Explain Conduction, Convection and Radiation Heat Transfer in Electronic Equipment **L:9**

Thermal Conductivity - Thermal Resistances - Conductivity in Solids, Fluids - Conduction in Simple Geometries: Plane Wall, Cylinders, Spheres, Plane Wall with Heat Generation, Extended Surfaces - Fin Efficiency, Fin Optimization, Fin Surface Efficiency,

Properties of Fluid - Boundary Layer Theory, Forced Convection: Laminar Flow, Turbulent Flow - Natural convection - Radiation Heat Transfer in Electronic Equipment: The Electromagnetic Spectrum, Radiation Equations, Stefan-Boltzmann Law, Surface Characteristics, Emittance, Absorptance – Reflectance - Environmental Effects - Solar Radiation and Atmospheric Radiation.

Combined Modes of Heat Transfer for Electronic Equipment : Conduction in Series and in Parallel - Conduction and Convection in Series - Radiation and Convection in Parallel.

CO3: Apply appropriate single-phase and two-phase cooling techniques to manage the thermal performance of electronic and power-electronic systems **L:9**

Introduction to Cooling Techniques: Air cooling - liquid cooling - cold plates - micro channel heat sinks - heat sink design and analysis - heat sink loss model.

Introduction to Two Phase Cooling: Heat pipes - principle and applications - vapor chambers - thermosyphons and capillary pumped loops - immersion cooling.

Power Electronics Thermal Challenges: Cooling strategies - jet and spray cooling - high heat flux cooling.

CO4: Analyze and apply thermal-management techniques in electrical and electronic systems **L:9**

Case studies: thermal management in data centers, power electronics automotive electronics, electric vehicle motors, batteries, solar photo voltaic, avionics data centers, and wearable.

CO5: Demonstrate temperature-measurement techniques and the use of thermal-simulation tools. **L:9**

Temperature Measurement – various methods. Thermal simulation tools - ANSYS - MATLAB to predict temperature distribution and optimize designs for better heat management.

TEXT BOOKS:

1. Thermal Management of Electronics by Y. Shabany, CRC Press, 2010.
2. Thermal Management of Microelectronic Equipment by L. T. Yeh, R. C. Chu, ASME Press, 2002.

REFERENCES:

1. Thermal Design of Electronic Equipment by Ralph Remsburg, CRC Press, 2001.
2. Heat and Mass Transfer: Fundamentals and Applications by Yunus Cengel, Afshin Ghajar, 2018
3. Fundamentals of Heat and Mass Transfer by Frank P. Incropera, 2013
4. Principles of Physics by Halliday, Resnick, Walker, 2014
5. Cooling Techniques for Electronic Equipment by D. Steinberg, WILEY, 1991.
6. Liquid Vapor Phase-Change Phenomena by V. P. Carey, CRC Press, 2020.
7. Heat Pipe Science and Technology by A. Faghri, Taylor and Francis, 1995.
8. Introduction to Heat Pipes by Bud Peterson, WILY, 1994.
9. Handbook of Thermal Engineering by R. P. Chhabra, CRC Press, 2018.
10. Fundamentals of Microsystems Packaging by R. R. Tummala, McGraw Hill, 2001.
11. Heat Transfer and Fluid Flow in Minichannels and Microchannels by S. Kandlikar, S. Garimella, D. Li, S. Colin, M. King, Elsevier, 2014.
12. Energy Efficient Thermal Management of Data Centers by Y. Joshi, P. Kumar, Springer, 2012.
13. Fundamentals of Heat and Mass Transfer by F. P. Incropera, D. P., Dewitt, T. L. Bergman, A. S. Lavine, WILEY, 2013.

L: 45; TOTAL: 45 PERIODS

Course Code	MACHINE LEARNING FOR ELECTRICAL ENGINEERING	L	T	P	E	C
23EE17E		3	0	0	0	3

COURSE OUTCOMES

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

Theory Component

CO1: Explain the fundamental concepts of Machine Learning and its types to understand the principles behind data-driven problem-solving.

CO2: Apply appropriate data preprocessing and dimensionality reduction techniques to prepare

datasets for model development.
CO3: Apply linear and nonlinear regression, neural networks, and SVMs for modeling and classification problems.
CO4: Analyze model evaluation and tuning strategies to assess and improve the performance of ML models in electrical engineering datasets.
CO5: Evaluate and design unsupervised and anomaly detection algorithms to identify abnormal events or patterns in electrical systems.

CO1: Explain the fundamental concepts of Machine Learning and its types to understand the principles behind data-driven problem-solving. **L:9**

Introduction to Machine Learning - Performance Measures, Bias-Variance Trade off - Types of Machine Learning - Supervised, Unsupervised, Reinforcement, and Evolutionary Learning - Regression fundamentals – Linear and Logic regression: Model Representation, Cost Function, Gradient Descent.

CO2: Apply appropriate data preprocessing and dimensionality reduction techniques to prepare datasets for model development. **L:9**

Data Cleaning, Handling Missing and Noisy Data - Data Integration, Redundancy and Correlation Analysis - Data Reduction techniques: PCA, LDA, ICA, Factor Analysis - Data Compression - Data Normalization and Discretization

CO3: Apply linear and nonlinear regression, neural networks, and SVMs for modeling and classification problems. **L:9**

Linear & Nonlinear Regression: Neural Network Model Representation - Multiclass Classification using NN, Cost Function, Back propagation, Gradient Checking, Random Initialization - SVM – Kernel functions and Classification

CO4: Analyze model evaluation and tuning strategies to assess and improve the performance of ML models in electrical engineering datasets. **L:9**

Evaluating Hypotheses - Model Selection and Train/Validation/Test Sets - Diagnosing Bias and Variance - Choosing Regularization Parameters - Learning Curve Analysis - Error Metrics for Skewed Classes - Precision–Recall Trade-offs – Fault classification in Electrical motors, transformers – State of Charge Estimation in EVs – Solar power prediction.

CO5: Evaluate and design unsupervised and anomaly detection algorithms in electrical systems. **L:9**

K-means Algorithm – Objectives, Centroid Initialization, Cluster Formation - Density Estimation and Threshold Selection - Building an Anomaly Detection System - Evaluation Metrics - Motor vibration or current-based anomaly detection.

REFERENCES:

1. Marsland, S. Machine Learning: An Algorithmic Perspective. 2nd Edition, Chapman & Hall/CRC Press, 2014.
2. Witten, I. H., Frank, E., & Hall, M. A. Data Mining: Practical Machine Learning Tools and Techniques. 4th Edition, Morgan Kaufmann/Elsevier, 2016.
3. Han, J., Pei, J., & Tong, H. Data Mining: Concepts and Techniques. 4th Edition, Elsevier, 2022.

4. van der Heijden, F., Duin, R., de Ridder, D., & Tax, D. M. J. Classification, Parameter Estimation and State Estimation: An Engineering Approach Using MATLAB. 2nd Edition, John Wiley & Sons, 2017.
5. https://www.coursera.org/learn/machine-learning
6. https://www.kaggale.com

L: 45; TOTAL: 45 PERIODS

Course Code	MICROCONTROLLER BASED SYSTEM DESIGN	L	T	P	E	C
23EE18E		3	0	0	0	3

COURSE OUTCOMES

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

Theory Component

CO1: Understand the fundamentals and requirements of processor functional blocks.
CO2: Analyze the features of RISC processor architecture and its operational mechanisms.
CO3: Develop I/O interfacing and peripheral control for processor-based systems.
CO4: Implement I/O software interfaces and signal processing techniques using ARM processors.
CO5: Explain the applications of PIC and ARM processors in automation, control, and IoT-based systems

CO1: Understand the fundamentals and requirements of processor functional blocks. **L:9**

PIC architecture, memory organization, addressing modes, and instruction set – PIC microcontroller programming in Assembly and C – I/O port configuration, data conversion, RAM and ROM allocation, timer programming, and practice using MPLAB.

CO2: Analyze the features of RISC processor architecture and its operational mechanisms. **L:9**

Overview of RISC architecture – ARM architecture and memory organization – addressing modes – ARM programmer's model – register organization – pipeline architecture – instruction execution – interrupts and exception handling – coprocessor interface – interrupt structure and vector table

CO3: Develop I/O interfacing and peripheral control for processor-based systems. **L:9**

PIC: ADC, DAC, and sensor interfacing – Flash and EEPROM memory interfacing – PWM generation – serial communication.
ARM: I/O memory and ports – EEPROM – SRAM – timer – UART – serial communication with PC – ADC/DAC interfacing – GPIO and peripheral control.

CO4: Implement I/O software interfaces and signal processing techniques using ARM processors. **L:9**

ARM general instruction set – Thumb instruction set – assembly and C programming for I/O interfacing – introduction to DSP on ARM – implementation of digital filters – arithmetic and logical operations – real-time signal processing applications

CO5: Explain the applications of PIC and ARM processors in automation, control, and IoT-based systems. **L:9**

PIC Implementation: Gate signal generation for converters and inverters – motor control – DC/AC appliance control – home automation – standalone data acquisition systems.
ARM Implementation: Assembly/C programs – loops – lookup tables – block copy – subroutines – smart agriculture and IoT applications.

TEXT BOOKS:

1. Steve Furber, "ARM system on chip architecture", Addison Wesley, 2010.
2. Andrew N. Sloss, Dominic Symes, Chris Wright, John Rayfield "ARM System Developer's Guide Designing and Optimizing System Software", Elsevier 2007.
3. David Seal, "ARM Architecture Reference Manual: ARMv8-A and ARMv9-A", Addison-Wesley, 2021.

REFERENCES

1. Muhammad Ali Mazidi, Rolin D. Mckinlay, Danny Causey "PIC Microcontroller and "Embedded Systems using Assembly and C for PIC18", Pearson Education 2008.
2. John Iovine, "PIC Microcontroller Project Book", McGraw Hill 2000
3. William Hohl, "ARM Assembly Language", Fundamentals and Techniques, 2009.
4. Rajkamal, "Microcontrollers Architecture, Programming, Interfacing & System Design,Pearson, 2012
5. Joseph Yiu, "The Definitive Guide to ARM Cortex-M3 and Cortex-M4 Processors", 3rd Edition, Elsevier, 2017.
6. ARM Architecture Reference Manual, LPC213x User Manual
7. www.Nuvoton.com/websites on Advanced ARM Cortex Processors.

L: 45; TOTAL: 45 PERIODS

Course Code	**DIGITAL SIGNAL PROCESSING**	**L**	**T**	**P**	**E**	**C**
23EE19E		**3**	**0**	**0**	**0**	**3**

COURSE OUTCOMES

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

Theory Component

CO1: Compute the frequency response using DFT and the FFT algorithms.
CO2: Design and realize IIR digital filters.
CO3: Design and realize FIR digital filters.
CO4: Recognize the effects of finite word length in DSP.
CO5: Outline the architecture and applications of digital signal processors.

CO1: Compute the frequency response using DFT and the FFT algorithms. **L:9**

Need and benefits of Digital Signal Processing – Signal classification - Fourier Series and Fourier Transform -Discrete Fourier Transform (DFT) - Properties – DIT-FFT and DIF-FFT radix2 algorithms - linear filtering via circular convolution - Inverse FFT

CO2: Design and realize IIR digital filters. **L:9**

Characteristics and applications of IIR filters - Design techniques for analog Butterworth and Chebyshev Filters -Frequency transformation - Digital IIR filter design: impulse invariant and bilinear transform methods – Canonical forms of Realization: direct, cascade, and parallel forms.

CO3: Design and realize FIR digital filters **L:9**

Symmetric and Antisymmetric FIR filters - Linear phase FIR filters – Characteristics and applications of FIR filters - Windowing Techniques - Design using Rectangular, Hamming, Hanning, Blackmann and Kaiser Windows - Realization of FIR filters**.**

CO4: Recognize the effects of finite word length in DSP. **L:9**

Fixed point and floating point number representations - Comparison - Truncation and Rounding errors A/D quantization noise – Product round off errors - Overflow error – Round off noise power - limit cycle oscillations due to product round off and overflow errors - Finite word length effects in IIR filters and FFT algorithms.

CO5: Outline the architecture and applications of digital signal processors. **L:9**

Architecture of TMS320LF2407 – On-chip peripherals – Addressing modes – Instruction set of TMS320LF2407 - selection of Processors - PWM generation – DSP based stepper motor control (Qualitative treatment only) - optimal filter- ARMA – LMS -Forward and Backward Linear prediction and FIR Wiener Filter.

TEXT BOOKS:

1. John G. Proakis, Dimitris G. Manolakis, “Digital Signal Processing: Principles, algorithms and applications”, 5th edition Pearson Prentice Hall, 2021.

REFERENCES:

1. Li Tan, Jean Jiang, “Digital Signal Processing: Fundamentals and applications” Academic press, 2018.
2. Salivahanan.S, Gnanpriya.C., “Digital Signal processing”, McGraw Hill, 2021.
3. Ifaeachor E.C, Jervis B. W., “Digital Signal processing: Practical approach”, Pearson publication, 2020.
4. Shaila Apte, “Digital Signal Processing”, Wiley India Publication, 2020.
5. Navas.K.A., Jayadevan.R., “Lab Primer through MATLAB”, PHI, 2021.

L: 45; TOTAL: 45 PERIODS

Course Code	**ADVANCED CMOS MICROFABRICATION**	**L**	**T**	**P**	**E**	**C**
23EE20E		**3**	**0**	**0**	**0**	**3**

COURSE OUTCOMES

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

Theory Component

CO1: Explain the fundamentals of microfabrication and apply SEMulator 3D to visualize basic virtual fabrication steps.

CO2: Describe semiconductor manufacturing steps with application of process concepts to interpret CMOS layouts in SEMulator 3D.

CO3: Explain the modules in advanced CMOS/FinFET processing and analyze changes in device architecture from planar MOSFET to FinFET.

CO4: Describe contact formation along with interconnect technologies with analysis of RC delay and electromigration challenges.

CO5: Explain ILD and low-k materials, apply 3D IC/TSV integration concepts, and analyze the performance differences between Planar FET and FinFET inverters.

CO1: Explain the fundamentals of microfabrication and apply SEMulator 3D to visualize basic virtual fabrication steps. **L:9**

Overview of the semiconductor industry and VLSI fabrication processes - Microfabrication and Moore's law, Semiconductor value chain: design, fabrication, packaging, system, product, Design Rules - Wafer Preparation - Circuit abstraction to layout and cross-section, Introduction to SEMulator 3D- Exploration of SEMulator 3D for virtual fabrication.

CO2: Describe semiconductor manufacturing steps with application of process concepts to interpret CMOS layouts in SEMulator 3D. **L:9**

Manufacturing process from SiO2 to the wafer, Wafer Modification, Deposition: Physical Vapor Deposition, Chemical Vapor Deposition, Electroplating, Lithography - Process Exploration of Spacer formation and Multiple Patterning Techniques in Advanced Lithography Photoresist-types. Etching: Wafer RCA cleaning, Wet etch, Dry etch, Isotropic versus anisotropic etch. Chemical-mechanical processing. Layout Design and Virtual Fabrication of NMOS, PMOS and CMOS inverter using SEMulator 3D.

CO3: Explain the modules in advanced CMOS/FinFET processing and analyze changes in device architecture from planar MOSFET to FinFET. **L:9**

Isolation module: Advantages and challenges of STI versus LOCOS. Device architecture: Planar to FinFET, use of SiGe and strain. Gate module: SiO_2 versus High-k dielectrics, polysilicon versus metal gate, gate-first versus gate-last, integration challenges of replacement metal gate. Well & junction module: Basics of implantation, source-drain and well implants, other implants.

CO4: Describe contact formation along with interconnect technologies with analysis of RC delay and electromigration challenges. **L:9**

Contact module: contact resistance issues of simple metal- silicon contact, metal silicide's, salicidation, evolution from Ti to Co to Ni silicide.

Interconnect module: Need for multiple metal layers, RC delay, challenge of electromigration, evolution from Al vs Cu, Damascene and dual-Damascene process, W plugs and via.

CO5: Explain ILD and low-k materials, apply 3D IC/TSV integration concepts, and analyze the performance differences between Planar FET and FinFET inverters. **L:9**

Intermediate dielectric: Need for ILD, low-k due to RC delay, SiO_2 to SiOF to SiOC to porous SiOC, material and integration challenges.

Emerging Trends - 3D ICs and Through-Silicon Vias (TSVs) Process integration-challenges in integration, yield and reliability considerations- Process study of Dual – Damascene technique for advanced interconnect fabrication- Comparative analysis of Planar FET and FINFET Inverter design and performance.

TEXT BOOKS:

1. Plummer, James D., and Peter B. Griffin. "Integrated Circuit Fabrication: Science and Technology", Cambridge University Press, 2023.
2. Stephen A. Campbell, "The Science and Engineering of Microelectronic Fabrication",

Oxford Press: New York, NY, USA, 2001.
3. Hilleringmann, Ulrich. "Silicon Semiconductor Technology: Processing and Integration of Microelectronic Devices"Springer Vieweg, 2023.

REFERENCES:

1. By Sorab K Ghandhi, “VLSI Fabrication Principles: Silicon and Gallium Arsenide”, 2nd Ed, John Wiley, 2008.
2. Richard C. Jaeger, “Introduction To Microelectronic Fabrication” Prentice hall, 2nd edition, 2002.
3. Swaminathan, Parasuraman, “Semiconductor materials, devices, and fabrication”, Wiley, 2017.

Web Sources:

1. nptel.ac.in/courses/102108078
2. https://www.lamresearch.com/product/semulator3d/

L: 45; TOTAL: 45 PERIODS

Course Code	VLSI DESIGN	L	T	P	E	C
23EE21E		3	0	0	0	3

COURSE OUTCOMES

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

Theory Component

CO1: Describe the operation of the MOS transistor and demonstrate the CMOS process technology.

CO2: Illustrate the various ASIC and FPGA architectures and the static timing analysis of the arithmetic building blocks.

CO3: Analyze CMOS circuits' for various delays and power dissipation.

CO4: Design and analyze the various techniques to optimize combinational and sequential circuits for lower delay.

CO5: Demonstrate the VLSI system components using Verilog HDL.

CO1: Describe the operation of the MOS transistor and demonstrate the CMOS process technology. **L:9**

MOS Transistor Theory - Ideal I-V and C-V Characteristics of MOS Transistor, Non-ideal I - V Effects, DC Transfer Characteristics of CMOS Inverter, N-wells**,** Twin Tub and SOI CMOS processes, Lambda-based design Rules, CMOS Process Enhancements

CO2: Illustrate the various ASIC and FPGA architectures and the static timing analysis of the arithmetic building blocks. **L:9**

Timing Analysis - Clock skew optimization – Clock Tree Synthesis., Full Custom ASICs, Standard Cell Based ASICs, Gate Array Based ASICs, Channeled, Channel-less, Structured Gate Array, and Architecture of Generic FPGA.

CO3: Analyze CMOS circuits' for various delays and power dissipation. **L:9**

Delay Estimation, Logical Effort and Transistor Sizing, Power Dissipation, Interconnect, Reliability, Scaling–Device models, Device characterization, Circuit characterization.

CO4: Design and analyze the various techniques to optimize combinational and sequential circuits for lower delay. **L:9**

Combinational Circuit Design: Circuit Families – Static CMOS, Ratioed Circuits, Dynamic CMOS Circuits, Pass-transistor logic Circuits, Comparison of CMOS Circuit Families, Sequential Circuit Design.

CO5: Demonstrate the VLSI system components using Verilog HDL. **L:9**

Design Methodologies – Modules – Instances – Test bench – Operators – Number Specification – Identifiers and Keywords – Data Types – Modules and Ports – Modelling: Structured Procedures, Procedural Assignments, - Design of combinational and sequential circuits using Gate-Level Modelling, Dataflow Modelling, Behavioural and Structural Modelling.

TEXT BOOKS:

1. Neil H. E. Weste and David Harris**,** *"*CMOS VLSI Design: A Circuits and Systems Perspective*",* 5th Edition**,** Pearson Education, 2022**.**
2. Samir Palnitkar**,** *"*Verilog HDL: A Guide to Digital Design and Synthesis*",* 2nd Edition**,** Pearson Education, Reprint 2021**.**

REFERENCES:

1. M. J. S. Smith**,** *"*Application-Specific Integrated Circuits*",* Pearson Education, 2019 (6th Reprint).
2. Jan M. Rabaey, Anantha P. Chandrakasan, and Borivoje Nikolić**,** *"*Digital Integrated Circuits: A Design Perspective*",* 2nd Edition, PHI Learning, 2018 (Reprint).
3. J. P. Uyemura**,** *"*Introduction to VLSI Circuits and Systems*",* Wiley, 2019**.**
4. Wayne Wolf**,** *"*Modern VLSI Design: Systems on Silicon*",* 3rd Edition**,** Pearson Education, 2019**.**

L: 45; TOTAL: 45 PERIODS

Course Code	**SPECIAL MACHINES AND DRIVES**	**L**	**T**	**P**	**E**	**C**
23EE22E		**3**	**0**	**0**	**0**	**3**

COURSE OUTCOMES

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

Theory Component

CO1: realize the operating modes, control and performance of stepper motor.
CO2: comprehend the structure, of SRM drive with its power converters and controllers.
CO3: illustrate the construction, operation and characteristics of Synchronous Reluctance Motor.
CO4: investigate the operation, characteristics and control of PMBLDC motor.
CO5: describe the construction, operation performance characteristics of PMSM and its power controllers

CO1: realize the operating modes, control and performance of stepper motor. **L:9**

Construction – Principle of Operation - Modes of Excitation – Torque Production – Characteristics - Linear and Non linear Analysis - Closed Loop control and Microprocessor based Control.

CO2: comprehend the structure, of SRM drive with its power converters and controllers. **L:9**

Construction – Principle of Operation – Voltage and Torque equation – Power converters and controllers – Control of SRM drive - Sensor less operation of SRM – Applications.

CO3: illustrate the construction, operation and characteristics of Synchronous Reluctance Motor **L:9**

Construction – Rotor design: Salient, Radially laminated and axially laminated - Working Principle – Torque speed characteristics – Phasor diagram – Synchronous reluctance hybrid motor.

CO4: investigate the operation, characteristics and control of PMBLDC motor. **L:9**

Fundamentals of Permanent Magnets – Types - Principle of operation - Magnetic circuit analysis - EMF and Torque equations - Characteristics and control

CO5: describe the construction, operation performance characteristics of PMSM and its power controllers **L:9**

Construction Features - Principle of operation – EMF and torque equations - Phasor diagram - Power controllers – Characteristics of synchronous reluctance motor - Digital controllers

TEXT BOOKS:

1. R.Krishnan, “Switched Reluctance motor drives”, CRC presses, 2017.
2. T.Kenjo, “Stepping motors and their microprocessor controls”, Oxford University press, New Delhi, 2017.
3. K.Venkataratnam, “Special Electrical Machines”, Universities Press, 2021.
4. Wei Hua, Peng Su, Gan Zhang, Guishu Zhao “Flux-Switching Machines” Wiley Encyclopedia of Electrical and Electronics Engineering, 2015.

REFERENCES:

1. R.Krishnan, “Electric motor drives”, Prentice Hall of India, 2015.
2. D.P.Kothari and I.J.Nagrath, “Electric machines”, Tata Mc Graw hill publishing company, New Delhi, Fifth Edition, 2017.
3. Irving L.Kosow, “Electric Machinery & Transformers”, Pearson Education, 2nd Edition, 2007.
4. Paul Acarnley, "Stepping Motors – A Guide to Motor Theory and Practice", Institution of Engineering and Technology, Fourth Edition, 2002.

L: 45; TOTAL: 45 PERIODS

Course Code	WIND AND SOLAR ENERGY SYSTEM	L	T	P	E	C
23EE23E		3	0	0	0	3

COURSE OUTCOMES

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

Theory Component

CO1: Discuss the role of renewable energy in world energy scenario and explain the fundamentals of energy storage devices.

CO2: describe the concepts of solar cell radiation and its measurement.

CO3: illustrate the solar cell characteristics and analyze the design of solar photovoltaic system

along with MPPT techniques.

CO4: depict the fundamentals of wind turbine concept of wind energy conversion system.

CO5: discuss the various generators used in WECS and describe the issues while the solar or wind connected with grid.

CO1: Discuss the role of renewable energy in world energy scenario and explain the fundamentals of energy storage devices. **L:9**

Energy, Economy & Social Development – Classification of Energy Resources – Importance of Renewable Energy Resources — Global Energy Scenario – Energy Audit –Energy Storage device - Sustainability and Environmental Aspects of Energy

CO2: describe the concepts of solar cell radiation and its measurement. **L:9**

Basics of Solar Energy – Sun, Earth, Radiation Spectrum – Extraterrestrial and Terrestrial Radiations – Depletion of Solar radiation – Measurement of Solar Radiation – Terrestrial Solar Radiation on Horizontal Surface

CO3: illustrate the solar cell characteristics and analyze the design of solar photovoltaic system along with MPPT techniques. **L:9**

Solar Cell Characteristics – Solar Cell design Consideration – reflective solar cell- Energy payback period – Solar Cell, Module and Array Construction – Effect of Shadowing – Maximum Power Point Tracking (MPPT) – Battery & Charge Controller Design – Solar PV system Design for small building and agriculture – Cost estimation.

CO4: depict the fundamentals of wind turbine concept of wind energy conversion system. **L:9**

Origin of winds – Nature of winds – Estimation of wind energy – Wind Turbine aerodynamics – Power Extraction of wind – Betz Criterion – Torque Developed – Tip Speed Ratio – Horizontal Axis Wind Turbine (HAWT) – Vertical Axis Wind Turbine (VAWT) – Case Study: Cost Estimation of Wind farm

CO5: discuss the various generators used in WECS and describe the issues while the solar or wind connected with grid. **L:9**

Wind Turbine characteristics – Components of Wind Energy Conversion System (WECS) – Fixed Speed Drive – Variable Speed Drive – Synchronous Generator – PMSG – Induction Generator – Doubly Fed Induction Generator – Grid connection Issues

TEXT BOOKS

1. Heir S., “Grid Integration of Wind Energy Conversion Systems”, Wiley, 2016.
2. Rai G.D., “Non-conventional Sources of Energy”, Khanna publishers, 2019.
3. B H Khan “Non-Conventional Energy Resources” McGraw Hill 3rd Edition 2021

REFERENCES

1. Himanshu Tyagi, Prodyut R. Chakraborty, “Solar Energy: Systems, Challenges, and Opportunities (Energy, Environment, and Sustainability)”, Springer, 2020.
2. Freris L.L., “Wind Energy conversion Systems”, Prentice Hall, 1990.
3. Ion Boldea, “Variable speed generators”, Taylor & Francis group, 2006.
4. Golding E.W., “Generation of Electricity by wind power”, Redwood burn Ltd., Trowbridge, 1976.

5. Chetan Singh Solanki, "Solar Photovoltaic's Fundamentals, Technologies and Applications", Prentice Hall Ltd., 2015.
6. James P. Dunlop, "Photovoltaic Systems", American Technical Publishers, 2009.
7. NREL (National Renewable Energy Laboratory) –Resources.

L: 45; TOTAL: 45 PERIODS

Course Code	**ELECTRICAL MACHINE DESIGN**	**L**	**T**	**P**	**E**	**C**
23EE24E		**3**	**0**	**0**	**0**	**3**

COURSE OUTCOMES

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

Theory Component

CO1: Identify the general design considerations of electrical machines.
CO2: Illustrate the design procedure of rotating DC machines
CO3: Examine the design of transformers according to standards
CO4: Recognize the enhanced dimension design of AC machines
CO5: Design the stator and rotor of synchronous alternators.

CO1: Identify the general design considerations of electrical machines. **L:9**

General design considerations, electrical engineering materials, space factor, choice of specific electric and magnetic loadings, types of enclosures - types of ventilation - Temperature rise calculation – rating of machines - Insulation classes – Introduction to modern insulating materials - Types of cooling in transformers and rotating electrical machines – Design Consideration for Energy Efficient Machines

CO2: Illustrate the design procedure of rotating DC machines **L:9**

Output Equations – Main Dimensions and design constraints – Choice of specific loadings – Selection of number of poles – Design of Armature – Design of air-gap - Design of commutator and brushes- Design of field winding - Estimation of performance and losses - Carter's Coefficient – Net length of Iron – Real & Apparent flux densities.

CO3: Examine the design of transformers according to standards **L:9**

Design of transformers - kVA output for single- and three-phase transformers, window space factor - Sizing of a transformer, main dimensions and design constraints, overall dimensions, no load current, temperature rise in transformers, design of cooling tank, methods for cooling of transformers - Essential design features of cast resin dry type transformers. Fundamentals of K-factor rated transformer, Energy Conservation Building Code (ECBC) standards for transformers, BEE Star rating of transformers.

CO4: Recognize the enhanced dimension design of AC machines **L:9**

Output Equations - main dimensions and design constraints - length of air gap, rules for selecting rotor slots of squirrel cage machines, design of rotor bars & end rings, design of wound rotor, magnetic leakage calculations, leakage reactance of poly phase machines, magnetizing current, short circuit current, Design aspects of induction motor for electric vehicles (qualitative treatment only).

CO5: Design the stator and rotor of synchronous alternators **L:9**

Output Equations - Sizing of a synchronous machine, main dimensions, design of salient pole machines, significance of short circuit ratio, choice of speed and number of poles - armature design, estimation of air gap length, design of rotor, design of damper winding, design of field winding, design of turbo alternators, rotor design, Analysis and synthesis methods – Case study: Design using modern tools.

TEXT BOOKS:

1. Sawhney A.K. and Chakrabarti A, "A Course in Electrical Machine Design", Dhanpat Rai & Sons, 2016.
2. Say .M.G, "The Performance and Design of Alternating current Machines", CBS Publishers & Distributors, 3rd edition, 2002.

REFERENCES:

1. IS 1180 (Part 1):2014, Bureau of Indian Standards. https://bis.gov.in
2. S.O. No. 4062 (E) for Distribution Transformer dated 16th December, 2016, Bureau of Energy Efficiency, Govt. of India, Ministry of Power. https://www.beestarlabel.com
3. M. V. Deshpande, "Design and Testing of Electrical Machines", Wheeler Publishing.
4. R. K. Agarwal, "Principles of Electrical Machine Design", Essakay Publications, Delhi.
5. Ramamoorthy M, "Computer Aided Design of Electrical Equipment", East-West Press.
6. S. K. Sen, "Principles of Electrical Machine Design with computer programmes", Oxford and IBH Publishing, 2006.
7. Clayton A E & Hancock N N, Performance and Design of DC Machines, ELBS, 1971.

L: 45; TOTAL: 45 PERIODS

Course Code	POWER ELECTRONICS APPLICATIONS TO POWER SYSTEMS	L	T	P	E	C
23EE25E		3	0	0	0	3

COURSE OUTCOMES

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

Theory Component

CO1: Summarize the need for FACTS controllers based reactive power compensation.
CO2: Illustrate the various applications of shunt compensators for power system.
CO3: Analyze the various series compensation techniques and elaborate the operation of TCSC.
CO4: Investigate the operation of Voltage Source Converter based FACTS controllers.
CO5: Describe the power quality conditioners interaction for the mitigation of harmonics

CO1: Summarize the need for FACTS controllers based reactive power compensation. **L:9**

General System considerations and FACTS: Transmission Interconnections, Power flow in an AC System, Dynamic Stability Considerations of a Transmission Interconnection, principles of series and shunt compensation, Basic configurations of FACTS Controllers, Application of FACTS

CO2: Illustrate the various applications of shunt compensators for power system. **L:9**

Shunt Compensation, Midpoint Voltage Regulation for Line Segmentation, End of Line Voltage Support to Prevent Voltage Instability, improvement of Transient Stability, Power Oscillation Damping, Static VAR Compensators, SVC, Configuration

and operating characteristics of TCR, FC-TCR, TSC, Comparison of SVCs. Dynamic Performance, Transient Stability, Enhancement and Power Oscillation Damping

CO3: Analyze the various series compensation techniques and elaborate the operation of TCSC. **L:9**

Concept of series capacitive compensation, voltage stability, improvement of transient stability, power oscillation damping, GTO thyristor controlled series capacitor, Thyristor controlled series capacitor , Advantages of the TCSC, Basic principle and different mode of operation, Analysis, Variable-reactance model and transient stability model of TCSC, SSSC.

CO4: Investigate the operation of Voltage Source Converter based FACTS controllers **L:9**

Introduction, Unified power flow controller - Operation, independent real and reactive power flow control, and control structure, basic control system for P and Q control.

CO5: Describe the power quality conditioners interaction for the mitigation of harmonics **L:9**

Power quality problems, harmonics, harmonic creating loads, harmonic power flow, and mitigation of harmonics, filters, passive filters, active filters, shunt, series and hybrid filters, Power Quality Conditioners; STATCOM - Uninterruptible Power Supplies, Power electronics in domestic and industrial loads; Power conditioning units for renewable power generation and distributed generation systems

TEXTBOOKS:

1. D. P. Kothari and I. J. Nagrath, “Modern Power System Analysis”, Tata McGraw Hill 2011.
2. A. J. Wood and B. F. Wollenberg, “Power generation, operation and control”, 3rd Edition, John Wiley and Sons, 2013.
3. Narain G. Hingorani, “Understanding FACTS - Concepts and Technology of Flexible AC Transmission Systems”, Standard Publishers Distributors, Delhi, 2011.

REFERENCES:

1. P. Kundur, “Power System Stability and control”, McGraw-Hill Edition 2008.
2. R.M.Mathur and R.K.Varma, “Thyristor Based FACTS Controllers for electrical Transmission systems”, John Wiley and sons 2002.
3. Ghosh, G. Ledwich, Power Quality Enhancement Using Custom Power Devices, Springer, 2012.

L: 45; TOTAL: 45 PERIODS

Course Code	**SOLID STATE DRIVES**	**L**	**T**	**P**	**E**	**C**
23EE26E		**3**	**0**	**0**	**0**	**3**

COURSE OUTCOMES

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

Theory Component

CO1: Realize the steady state operation and transient dynamics of a drive load system.
CO2: Analyze the operation of the converter & chopper fed dc drive
CO3: Discuss the operation and performance of AC Induction motor drives.

CO4: Describe the operation and performance of AC Synchronous motor drives.
CO5: Analyze and design the current and speed controllers for a closed-loop solid-state DC motor drive.

CO1: Realize the steady state operation and transient dynamics of a drive load system **L:9**

Electric drive – Equations governing motor load dynamics – steady state stability – multi-quadrant Dynamics: Acceleration, Deceleration, Starting &Braking – typical load torque characteristics –Selection of motor.

CO2: analyze the operation of the converter & chopper fed dc drive **L:9**

Steady state analysis of fully controlled converter fed separately excited DC drive – Continuous and discontinuous conduction – Time ratio and current limit control – Four-quadrant operation of chopper-fed drive

CO3: discuss the operation and performance of AC Induction motor drives. **L:9**

PWM techniques- Stator voltage control – V/F control – vector control- Constant air gap flux – Field weakening mode – voltage / current fed inverter – closed loop control.

CO4: Describe the operation and performance of AC Synchronous motor drives. **L:9**

V/f control and self-control of synchronous motor: Margin angle control and power factor control – Operation from fixed Frequency – Synchronous motor variable speed drives

CO5: analyze and design the current and speed controllers for a closed loop solid state DC motor drives. **L: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 – Energy Efficient Industrial Drives – PLC based Industrial Drives (Qualitative treatment only).

TEXT BOOKS:

1. Dubey.G.K., "Fundamentals of Electrical drives", Narosa publications, 2010.
2. Bimal K. Bose., “Modern Power Electronics and AC Drives”, Prentice Hall / Pearson Education Private Limited, 2017.

REFERENCES:

1. De N. K. and Sen P. K., “Electrical Drives”, Prentice Hall Private Limited, 2012.
2. Murphy J.M.D. and Turnbull, “Thyristor control of AC Motor”, Pergamon Press Oxford, 2014.
3. Krishnan R., “Electric Motor Drives: Modeling, Analysis, and Control”, Wiley, 2014.
4. Gopal K. Dubey, “Power Semi conductor controlled drives”, Prentice Hall Private Limited, 2014.
5. Vedam Subramanyan, “Thyristor control of Electrical Drives”, Tata McGraw Hill Private Limited, 2017.
6. Handbook on Facts worth Knowing about Frequency Converters, Danfoss Power Electronics, 2014.

L: 45; TOTAL: 45 PERIODS

Course Code	SWITCHED MODE POWER CONVERSIONS	L	T	P	E	C
23EE27E		3	0	0	0	3

COURSE OUTCOMES

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

Theory Component

CO1: Summarize the basic concepts of DC-DC converters
CO2: Infer the working of advanced power converters of SMPCs.
CO3: Analyze the performance of soft switching converters.
CO4: Apply various modulation and power conditioning techniques for the inverters.
CO5: Interpret the role of UPS and filters in SMPS

CO1: Summarize the basic concepts of DC-DC converters **L:9**

Introduction - Key building blocks of SMPS - Overview of Buck, Boost, Buck-Boost and Cuk Converters - SEPIC converter –- Industrial relevance - SMPC requirements.

CO2: Infer the working of advanced power converters of SMPCs. **L:9**

Introduction - Analysis of fly back converters - forward converters, Luo converters, Half bridge and full bridge converters – Single-switch and multi-switch transformer-isolated DC-DC converters - Control Circuits – PWM Techniques

CO3: Analyze the performance of soft switching converters. **L:9**

Introduction – Classification – basic concepts of resonant switching - Load Resonant Converters – Zero Voltage Switching (ZVS) - Zero Current Switching (ZCS) - Clamped voltage topologies – DC link inverters with zero voltage switching - Series and parallel resonant inverters – Voltage control techniques

CO4: Apply various modulation and power conditioning techniques for the inverters. **L:9**

Single phase and three phase inverters, Control using various PWM techniques (Sine PWM, SVPWM and advanced modulation) – Introduction to Power Line Disturbances – Power Conditioners – harmonic elimination techniques – Multilevel inverters – Concepts – Types: Diode clamped – Flying capacitor – Cascaded type – Applications.

CO5: Interpret the role of UPS, filters in SMPS **L:9**

Uninterrupted Power Supply (UPS) Topologies – Filters: Filter for PWM VSI, Current filter, DC filters, Design of Inductor and transformer for SMPS – Selection of capacitors - Protection Circuits - IEC standards for SMPS (Safety and EMI/EMC standards) – Design aspects and constraints for SMPS – Case Study on EV charging design

TEXT BOOKS:

1. Umanand L.,"Power Electronics Essentials and applications" , Wiley, 2021.
2. Rashid M.H., "Power Electronics handbook" Elsevier Publication, 2022
3. Ramanarayanan V., "Course Material on Switched Mode Power Conversion", IISc Bangalore, 2022.

REFERENCES:

1. Rashid M.H., "Power Electronics: Circuits, Devices and Applications", 3rd Edition, Pearson Education, 2018.

2. Ned Mohan, Tore M. Undeland, William P. Robbins, "Power Electronics: Converters, Applications and Design", 3rd Edition, John Wiley and Sons, 2018.
3. Philip T. Krein, "Elements of Power Electronics", Oxford University Press, 2012

L: 45; TOTAL: 45 PERIODS

Course Code	POWER ELECTRONICS FOR RENEWABLE	L	T	P	E	C
23EE28E	ENERGY SYSTEMS	3	0	0	0	3

COURSE OUTCOMES

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

Theory Component

CO1: explore the structure of renewable energy systems and impact of renewable energy technologies on the environment.

CO2: Examine the design of power converters for solar photovoltaic systems & investigate the types of PV system along with grid connection issues.

CO3: Analyze the power converters for wind energy conversion system and illustrate the suitable electrical machine for WECS

CO4: interpret the need of hybrid renewable energy system and investigate the importance of maximum power point tracking

CO5: Design and develop the solar and wind system with appropriate energy demand using MATLAB platform.

CO1: explore the structure of renewable energy systems and impact of renewable energy technologies on the environment. **L:9**

Need and impact of non conventional energy sources –Operating Principle & Characteristics: Solar, Wind, Ocean, Geothermal, Fuel cell, Biomass and Hydrogen Energy System – Energy Scenario – Environmental aspects of Energy – GHG Emission

CO2: Examine the design of power converters for solar photovoltaic systems & investigate the types of PV system along with grid connection issues **L:9**

Overview of Solar Photovoltaic system – Line Commutated Converter – DC-DC Converter – Inverter Selection – Battery & Array Sizing – Standalone PV system – Grid Interactive PV system – Grid Connection issues.

CO3: Analyze the power converters for wind energy conversion system and illustrate the suitable electrical machine for WECS **L:9**

Wind Energy Conversion System (WECS) - Three-phase AC voltage controllers- AC-DC-AC converters - PWM Inverters, Grid-Interactive Inverters - Matrix converter – Grid Integrated SCIG, PMSG & DFIG based WECS – Standalone fixed and variable speed WECS

CO4: interpret the need of hybrid renewable energy system and investigate the importance of maximum power point tracking **L:9**

Need for Hybrid system – Requirement and Types of Hybrid System – Case study:

PV/Diesel Hybrid system – Wind/Diesel Hybrid System – Wind/PV hybrid System – Maximum Power Point Tracking – Algorithm of MPPT

CO5: Design and develop the solar and wind system with appropriate energy demand using MATLAB platform **L:9**

Design of Solar system – Design calculation for Buck/Boost/Buck Boost Converter – Modelling in MATLAB/Simulink – Design of WECS - Design calculation for DC/AC Converter - Modelling and Simulation of PMSG Based Wind Power Generation System.

TEXT BOOKS:

1. Rashid .M. H. "Power electronics Hand book", Academic press, 4th Edition, 2018.
2. Haitham Abu-Rub, Mariusz Malinowski, Kamal Al-Haddad "power electronics for renewable Energy systems", Transportation and Industrial Applications. Wiley IEEE Press, 2021
3. B.H.Khan, "Non-conventional Energy sources", Tata McGraw-hill Publishing Company, New Delhi, 2017.

REFERENCES:

1. Rai. G.D, "Non-conventional energy sources", Khanna publishers, 6th Edition 2019.
2. Gray, L. Johnson, "Wind energy system", prentice hall of India, 2015.
3. R.Seyezhai, R.Ramaprabha, "Power Electronics for Renewable Energy Systems", Scitech Publications, 2020
4. Teuvo Suntio and Tuomas Messo ""Power Electronics for Renewable Energy Systems", Energies, 2019.
5. S.N.Bhadra, D. Kastha, & S. Banerjee "Wind Electrical Systems", Oxford University Press, 2019.

L: 45; TOTAL: 45 PERIODS

Course Code	DESIGN OF PHOTOVOLTAIC SYSTEMS	L	T	P	E	C
23EE29E		3	0	0	0	3

COURSE OUTCOMES

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

CO1: Describe the Photovoltaic Characteristics and Interconnections of Cells and Modules

CO2: Design solar energy systems integrating radiation analysis, photovoltaic sizing

CO3: Design solar PV systems with battery sizing, MPPT, converters, and charge controllers.

CO4: Analyze grid interface systems and inverter control techniques for renewable energy integration.

CO5: Estimate life cycle cost and analyze economic sustainability of solar PV systems.

CO1: Describe the Photovoltaic Characteristics and Interconnections of Cells and Modules **L:9**

Brief history-PV cell-Model of PV cell-I-V characteristics - cell efficiency - effect of temperature -fill factor-data sheet-example-simulation-identical cells in series-load line-Series and parallel connection of identical and non-identical cells-protecting and interconnecting modules-simulation model of PV source.

CO2: Design solar energy systems integrating radiation analysis, photovoltaic sizing **L:9**

Introduction-solar radiation terms-estimation of daily irradiance-irradiance and insolation-incident energy and declination-solar geometry-insolation on horizontal and tilted flat plate collectors-daily energy calculation -optimum fixed tilt angle determination for solar collectors-atmospheric effects -energy analysis on vertically placed solar collectors-PV system sizing for applications without battery -cleaning, maintenance of PV systems

CO3: Design solar PV systems with battery sizing, MPPT, converters, and charge controllers. **L:9**

Load Profile and days of Autonomy-Battery sizing – PV array sizing -Maximum Power Point Tracking (MPPT) - Input resistance of boost, buck, and buck-boost converters-input impedance of isolated converters -MPPT through input resistance control - Battery charging – Direct connection and charge controller concepts-charge controller Circuits – Switched Mode charging and MPPT integration-Battery configurations – series, parallel, and equalization techniques.

CO4: Analyze grid interface systems and inverter control techniques for renewable energy integration. **L:9**

Grid Interaction - Introduction - Interconnection principle - Controlled inverter source
- T-Network - Characteristic impedance - Propagation constant - L-C-L interface
Transformer-less versus galvanic isolation - Single phase grid interface - Open loop plant - Gate drive - PWM - α, β currents - Stationary to rotating frame transformation-
Frequency and angle estimation – Feed forward components - MPPT integration
Three phase grid interface

CO5: Estimate life cycle cost and analyze economic sustainability of solar PV systems. **L:9**

Life Cycle Cost - Introduction - Growth models - Linear growth - Compound growth - Exponential growth - Inflation - Time frame transformation - Annual payments - Life cycle costing - Examples - Estimation of LCC, ALCC , breakeven point – sustainable analysis of solar PV systems.

TEXT BOOKS:

1. Umanand, L."Design of photovoltaic systems" Wiley India Pvt. Ltd., 2019.
2. Chetan Singh Solanki, Solar Photovoltaics: Fundamentals, Technologies And Applications 3rd Edition, PHI 2015

REFERENCES:

1. Thomas E. Kissell, David M. Buchla, Thomas L. Floyd, "Renewable Energy Systems", Pearson Education, 1st Edition, 2014.
2. Sawhney G. S., Non-Conventional Energy Resources, PHI Learning, 2012.
3. Tara Chandra Kandpal, Hari Prakash Garg, "Financial Evaluation of Renewable Energy Technologies", Macmillan India Limited, 1st Edition, 2003.
4. Abbasi S. A. and Tasneem Abbasi, "Renewable Energy Sources: Their Impact on Global Warming and Pollution", PHI Learning Pvt. Ltd., 1st Edition, 2010.

5. D.P. Kothari, M Jamil. Grid Integration of Solar Photovoltaic Systems, CRC Press 2018.
6. G.N. Tiwari: Solar Energy-Fundamentals, Design, Modelling and Applications, Narosa Publishers,2002
7. A.A.M. Saigh(Ed): Solar Energy Engineering, Academic Press, 1977

L: 45; TOTAL: 45 PERIODS

Course Code	ELECTRONICS DESIGN AND TECHNOLOGY	L	T	P	E	C
23EE30E		3	0	0	0	3

COURSE OUTCOMES

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

Theory Component

CO1: Analyze the characteristics of passive components, network theorems, in electrical circuits.
CO2: Design and analyze basic diode and transistor circuits for regulation, switching, and interfacing.
CO3: Develop op-amp based signal conditioning and data conversion applications circuits.
CO4: Apply digital design concepts to develop logic circuits, counters, communication interfaces.
CO5: Develop power supply circuits incorporating regulators, protection devices, and DC-DC converters.

CO1: Analyze the characteristics of passive components, network theorems, in electrical circuits. **L:9**

Review of Resistor, Inductor, Capacitor – Types – selection, ratings – Reactance – Data sheet approach – Review of Network Reduction (R/L/C) - Star delta conversion – Heat dissipation – Energy stored – Voltage and Current Division – Resistance Inductance Capacitor Behavior in AC and DC Circuits RC, LC circuits – Filters – Transient Characteristics – Applications of Network Theorems – DC sources with clamping concepts – Battery – Serial and Parallel - Ah calculations – Ohm meter concepts – Ammeter – Voltmeter– internal resistance - Range modification - shunt calculation –PWM for Variable DC concepts.

CO2: Design and analyze basic diode and transistor circuits for regulation, switching, and interfacing. **L:9**

Review of Diode Circuits – Design of wave shaping circuits – Design of Zener voltage regulator, threshold, Power and Resistor– Limiter – BJT- gain in various configuration – load line - V/I calculation for various region of operation – Darlington as buffer – datasheet – BJT as switch – Relay interfacing – BJT JFET comparison – JFET circuits design – variation in channel resistance – MOSFET – Operating Region – different circuits design – Current Mirrors – design of LED and opto coupler circuits.

CO3: Develop op-amp based signal conditioning and data conversion applications circuits. **L:9**

Review of op-amp characteristics – open loop, closed loop concepts –positive and Negative feedback – importance of a Buffer – sensor interfacing – Application circuits of amplifier, summer, integrator/differentiator, comparator with AC/DC inputs – precision rectifiers – peak detector – S&H circuits – Application circuits of

First order LPF, HPF, BPF, BRF – compensation – clock and delay generating circuits - ADC concepts review, Resolution

CO4: Apply digital design concepts to develop logic circuits, counters, communication interfaces. **L:9**

Review of number system and conversion – TTL and CMOS concepts – Gates formation using Diode, Transistor and MOSFET, Universal Gates – Realization of gates – Application circuits of Gates and Flip flops – Latch and Buffer – Edge level triggering – Design of Counters – encoder, decoder Mux and Demux Concepts – Serial communication – SPI I2C protocols and its concepts – Clock generation circuits – high precision oscillators – DAC concepts.

CO5: Develop power supply circuits incorporating regulators, protection devices, and DC-DC converters. **L:9**

Design of Power supply Circuits – Output voltage, power calculations – Selection of devices – Filters design – EMI suppressor – ESD concepts – Transient Voltage Suppresser – Metal Oxide Varistor – Need of Regulator - Design of LMPS with regulator – Fixed Regulator ICs – Design of Variable power supply – HF ripple reduction techniques – signal and power supply ground – DC to DC Conversion– SMPS – Block diagram – importance – difference between LMPS and SMPS – Fast Recovery - Schottky diode.

TEXT BOOKS:

1. Sudhakar A and Shyam Mohan S.P, Circuits and Network Analysis and Synthesis, Tata McGraw-Hill, New Delhi, 2010
2. Robert L. Boylestad and Louis Nashelsky, Electronic Devices and Circuit Theory, 11th Edition., Pearson / Prentice Hall, 2012
3. Jacob Millman and Christos C. Halkias, *Integrated Electronics:* Analog and Digital Circuits and Systems, 2nd Edition. (reprint 2017), McGraw-Hill.
4. Thomas L. Floyd, *Digital Fundamentals*, 11th Edition, Pearson Education Inc. (Global), 2015 (print), updated 2021/2025 for Global Edition.

REFERENCES:

1. Keith H. Billings, Switchmode Power Supply Handbook, 3rd Editon., McGraw-Hill Professional, 2010.
2. S. Salivahanan, N. Suresh Kumar, and A. Vallavaraj, Electronic Devices and Circuits, 4th Edition, McGraw-Hill Education (India), 2021.
3. Donald D. Givone, Digital Principles and Design, 1st Edition, Tata McGraw-Hill, New Delhi, 2003.

L: 45; TOTAL: 45 PERIODS

Course Code	LOGIC AND DISTRIBUTED CONTROL SYSTEM	L	T	P	E	C
23EE31E		3	0	0	0	3

COURSE OUTCOMES

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

Theory Component

CO1: Demonstrate the hardware components and Programming with PLC.
CO2: Develop PLC programming routines with the instructions in PLC.

CO3: Use the standards and safety precautions in PLC installation.
CO4: Interpret the functionality of SCADA for real applications
CO5: Sketch the architecture of DCS and its hierarchical communication topologies.

CO1: Demonstrate the hardware components and Programming with PLC **L:9**

Advantages of PLC over relay logic – Parts of PLC –Architecture – Principles of operation – scan time and scan cycle – PLC versus Computer – PLC Size and Application – PLC Hardware components – Basic ladder program instruction – Interlocks - Programming timers and counters – Ladder logic program with basic instructions.

CO2: Develop the PLC programming routines with the instructions in PLC. **L:9**

Advanced Instructions in PLC – Program control instructions – Data manipulation instructions – math instructions – sequencer and shift register instructions – Ladder logic program with advanced instructions.

CO3: Use the standards and safety precautions in PLC installation **L:9**

PLC Installation Practices – Editing and Troubleshooting –Data acquisitions system – System integrity and safety – fail safe wiring and programming – system interlocks – time synchronization – time stamping events - Application of PLC in industry.

CO4: Interpret the functionality of SCADA for real applications **L:9**

SCADA Functional requirements and Components – General features – Configurations - Remote Terminal Units as PLC – Master-slave concept - watchdog controller for error detection – H/W and S/W fault detection–SCADA Communication Protocol DNP3, IEC 61850 - Field bus – Profibus – Application in power sector, oil & gas industry.

CO5: Sketch the architecture of DCS and its hierarchical communication topologies **L:9**

Functional Requirements- Evolution of Architectures – Central Vs distributed control - Local control unit –Process interfacing issues –Operator interfaces –Engineering interfaces - Communication options –Low level and high level control topology - GPS clock synchronizer in DCS – Case Study.

TEXT BOOKS

1. Petruzella, "Programmable Logic Controller", Tata McGraw Hill Private Limited, 5th Edition, 2017.
2. Krishna Kant, "Computer based Industrial Control", Prentice Hall Private Limited, New Delhi, 2014.

REFERENCES:

1. T. Hughes, "Programmable Logic Controllers", ISA press, 2007.
2. Clarke, G., Reynders, D. and Wright, E., "Practical Modern SCADA Protocols: DNP3,4. 60870.5 and Related Systems", Newnes, 1st Edition, 2004
3. Michael P. Lukas, "Distributed Control System", Van Nostrand Reinhold Co., Canada, 2001
4. http://nptel.ac.in/courses/108106022
5. M. Chidambaram, "Computer Control of Processes", Narosa Book Distributors Private Limited, 2002.

L: 45; TOTAL: 45 PERIODS

Course Code	INTELLIGENT SENSORS AND	L	T	P	E	C
23EE32E	INSTRUMENTATION	3	0	0	0	3

COURSE OUTCOMES

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

Theory Component

CO1: Describe the importance of sensors with intelligent instrumentation for real application.
CO2: Comprehend the types of intelligent sensors useful various applications.
CO3: Explain the process of fabricating the smart sensors with cutting edge technology
CO4: Illustrate the communication protocols for effective interfacing of smart sensors.
CO5: Demonstrate the operation of DAQ in interfacing instruments to PC using LabVIEW.

CO1: Describe the importance of sensors with intelligent instrumentation for real application **L:9**

Sensor and transducer - Classification of sensors on the basis of energy source and type of output signals – Actuators and its types – features of Intelligence- Components of intelligent instrumentation system –Intelligent sensors application: case study on Smart Car.

CO2: Comprehend the types of intelligent sensors useful various applications **L:9**

Intelligent Sensors: Introduction – Classification: Smart Sensors, Cogent Sensors, Soft Sensors, Self-Adaptive Sensors, Self-Validating Sensors, Neuro sensors, Biosensors, Temperature Compensating Intelligent Sensors – MEMS and Nano-Sensors –Film sensors (Thick film sensors, thin film sensor),

CO3: Explain the process of fabricating the smart sensors with cutting edge technology **L:9**

Manufacturing smart sensors - Thin film, Thick-film and monolithic IC technologies - Bulk and surface micromachining technologies, wafer bonding, LIGA process, plasma etching.

CO4: Illustrate the communication protocols for effective interfacing of smart sensors **L:9**

Sensor Networking: 7-Layer OSI model of communication system–Network topology – 2 wire and 4 wire transmitters – protocols for wired and wireless LANs–WiFi, Ethernet, RS-485, Fieldbus protocols- HART protocol -adhoc networks - Smart Transducer Interface Standard IEEE

CO5: Demonstrate the operation of DAQ in interfacing instruments to PC using LabVIEW **L:9**

Sensor Interfacing using DAQ - software structurefor data sockets -Communication Network - Data Acquisition with LabVIEW and DAQ Vis: waveform, data type, ELVIS interfacing with Assistants: RS232C versus GPIB, handshaking, GPIB interfacing, RS232C/RS485 interfacing, VISA - Instrument interfacing inLabVIEW

TEXT BOOKS:

1. M. Bhuyan, “Intelligent Instrumentation Principles and Applications”, CRC Press 2011
2. Randy Frank, “Understanding Smart Sensors” 3rd Edition, Kindle Edition 2013

REFERENCES:

1. Changjian Deng, “Modern Intelligent Instruments - Theory and Application”, Bethambooks 2020.

2. Fraden J., "Handbook of Modern Sensors: Physics, Design and Applications", 4th Edition, AIP press 2010.
3. Barney, G.C., Intelligent instruments, Hemel Hempsteao: Prentice Hall 1988
4. S. Gupta / P.C Interfacing for data Acquisition & Process Control, 2nd Edition / Instrument Society of America, 1994.
5. Lisa,K. Wells & Jeffery Travis, "Lab VIEW For everyone", 3rd Edition, Prentice Hall, 2006.

L: 45; TOTAL: 45 PERIODS

Course Code	ADVANCED CONTROL THEORY	L	T	P	E	C
23EE33E		3	0	0	0	3

COURSE OUTCOMES

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

Theory Component

CO1: Demonstrate the characteristics of nonlinear systems.
CO2: Calculate the stability of the system using Lyapunov theorem.
CO3: Interpret the parameters to design optimal control problems.
CO4: Demonstrate the significance of robustness of controller design.
CO5: Develop adaptive control scheme with model reference.

CO1: Demonstrate the characteristics of nonlinear systems **L:9**

Methods of linearization– Phase plane analysis of non-linear system– Derivation of describing functions for common nonlinearities – Describing function analysis of non-linear systems – limit cycles - Singular points – Stability of oscillations.

CO2: Calculate the stability of the system using Lyapunov theorem. **L:9**

Lyapunov stability definition – Lyapunov stability theorem – Lyapunov functions for nonlinear system – Krasovskii method – Variable gradient method – Direct method of Lyapunov and linear systems.

CO3: Interpret the parameters to design optimal control problems **L:9**

Parameter optimization: Servo mechanism – Optimal control problems: Transfer function and State variable approaches – State regulator problem – Infinite time regulator problem– Output regulator and Tracking problem – Parameter optimization: regulators – Linear Quadratic Regulator.

CO4: Demonstrate the significance of robustness of controller design **L:9**

Sensitive parameters of system – Analysis of robustness – Systems with uncertain parameters – Design of robust control systems – PID controller – H ∞ Control - Design of robust PID controller – Design of robust internal model control system – Pseudo quantitative feedback system.

CO5: Develop adaptive control scheme with model reference **L:9**

Model reference adaptive control – MIT rule – MRAC using Lyapunov theory – First order systems –higher order systems – MRAC for a single link manipulator – Self tuning control.

TEXT BOOKS:

1. Gopal M, "Modern Control System Theory", New Age International, 5th Edition, 2024.
2. Richard C. Dorf and Robert H Bishop, "Modern control systems", 14th Edition, Addison

Wesley, 2022.

REFERENCES:

1. Gopal M, "Control Systems Principles and Design" McGraw Hill Education ,4th Edition 2013.
2. Cheng D, Sun Y, Shen T and Ohmori H, "Advanced Robust and Adaptive Control Theory and Applications", New Age International, 2010
3. Astrom KJ & Wittenmark B, "Adaptive Control", Dover Publications, 2013.
4. Kirk D.E, "Optimal Control Theory: An Introduction", Dover Publications, 2012.
5. B.C.Kuo," Digital Control Systems", SRL Publication, 2003

L: 45; TOTAL: 45 PERIODS

Course Code	SUBSTATION AUTOMATION	L	T	P	E	C
23EE34E		3	0	0	0	3

COURSE OUTCOMES

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

Theory Component

CO1: Explain the functional components and layout of modern substations.
CO2: Describe the architecture and communication protocols used in substation automation systems.
CO3: Apply knowledge of Intelligent Electronic Devices (IEDs) and their role in monitoring, control, and protection.
CO4: Apply Computer control to the Modern Substation
CO5: Design of Substation Automation and Case Studies

CO1: Explain the functional components and layout of modern substations. **L:9**

Overview of Power system substation- Types of Substation- Components of substations- Need for automation in substations- Modern grid and Substation Automation- Benefits of Substation Automation System-Hierarchical structure: station level, bay level, process level- substation integration and automation system.

CO2: Describe the architecture and communication protocols used in substation automation systems. **L:9**

Functional architecture - Substation automation: Distributed structure, Centralized structure - Substation integration and automation technical issues Communication architectures – substation networking – protocols: IEC 60870-5, DNP3, MODBUS- introduction to IEC 61850 standard- Data Modelling concept- GOOSE messages, sampled values- Ethernet based communication and redundancy concept.

CO3: Apply knowledge of Intelligent Electronic Devices (IEDs) and their role in monitoring, control, and protection. **L:9**

Functions and roles of IEDs in substation – protection, control, and metering IEDs – data acquisition – Configuration and parameter settings of IED - interoperability and data exchange among IED – process bus and station bus concepts- Implementation.

CO4: Apply Computer control to the Modern Substation **L:9**

Need of computer control of power system -Energy Control Centre and their functions- SCADA systems –Hardware Configurations-Various operating states of a Power System- State-estimation- Preventive and Emergency Control- Phasor Measurement Units (PMU) -

Wide Area Monitoring, Protection and Control (WAMPAC) -Bay Control Unit.

CO5: Design of Substation Automation and Case Studies **L:9**

Design of Principle of substation automation systems – integration with legacy equipment in modern power system – cyber security in substations communication Network – testing and commissioning – IEC 61850–based digital substations- Different case studies on substation Automation.

TEXT BOOKS:

1. Evelio Padilla, "Substation Automation Systems: Design and Implementation", Wiley, 2015
2. Yuan, Yubo & Yang, "IEC 61850-Based Smart Substations: Principles, Testing, Operation and Maintenance", 1st Edition, 2019

REFERENCES:

1. Patki, Dinkar and Singh. "Manual on substation Automation System" central board of Irrigation and Power 2021
2. Klaus-Peter Brand, Volker Lohmann & Wolfgang Wimmer, "Substation Automation Handbook", Utility Automation Consulting Lohmann, 1st Edition, 2003

L: 45; TOTAL: 45 PERIODS

Course Code	MOBILE ROBOTICS AND CONTROL	L	T	P	E	C
23EE35E		3	0	0	0	3

COURSE OUTCOMES

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

Theory Component

CO1:Summarize the configuration of mobile robot for various applications
CO2: Develop the kinematic and dynamics model of mobile robot.
CO3: Illustrate the robot navigation with localization and mapping
CO4: Investigate the environment around the robot using image processing techniques.
CO5: Design mobile robot for real time navigation and control.

CO1: Summarize the configuration of mobile robot in various applications **L:9**

Introduction: mobile robots & mobile manipulators – Locomotion - Types: Wheeled mobile robots - Unmanned Ground Vehicle, Unmanned Water Vehicle - Drones - Sensors: magnetic & optical position sensor, gyroscope, accelerometer, tactile & proximity sensors, rangefinder – Radar, laser scanner – LIDAR.

CO2: Develop the kinematic and dynamics model of mobile robot. **L:9**

Wheeled mobile robot: Kinematics model – Degree of Freedom (DOF) – maneuverability - different wheel configurations – workspace – frames - Generalized wheel model - holonomic and non-holonomic robots -Dynamics of mobile robot: Lagrange-Euler and Newton-Euler methods.

CO3: Illustrate the robot navigation with localization and mapping **L:9**

Localization: Error propagation model, Belief representation - Map Representation - Probabilistic map-based localization –Robot navigation – Motion and path planning: collision free path planning and sensor-based obstacle avoidance.

CO4: Investigate the environment around the robot using image processing techniques. **L:9**

Camera coordinates–types of camera - Image representation–threshold – BLOB analysis –AI based object recognition: Alex net, Google net - Noise and Edges detection - convolution masks- Processing techniques – semantic segmentation.

CO5: Design mobile robot for real time navigation and control. **L:9**

Motion control of mobile robots - Motion controlling methods, kinematic control, dynamic control and cascaded control – Case studies: QBOT 2 robot, Aerial vehicles - wireless connected robot – agent control - Swarm robots, cooperative and collaborative robots.

TEXT BOOKS:

1. R Siegwart, IR Nourbakhsh, D Scaramuzza, Introduction to Autonomous Mobile Robots, MIT Press, USA, 2011.
2. Gregor Klancar, Andrej zdesar, Sasa Blazic, Igor Skrjanc, "Wheeled mobile robotics", Elsevier, 2017.

REFERENCES:

1. Eugene Kagan, Nir Shvalb, Irad Ben-Gal, "Autonomous Mobile Robots and Multi- Robot Systems: Motion- Planning, Communication, and Swarming" Wiley publication 2020.
2. SG Tzafestas, Introduction to Mobile Robot Control, Elsevier, USA, 2014.
3. A Kelly, Mobile Robotics: Mathematics, Models, and Methods, Cambridge University Press, USA, 2013.
4. S Thrun, W Burgard, D Fox, Probabilistic Robotics, MIT Press, USA, 2005
5. G Dudek, M Jenkin, Computational Principles of Mobile Robotics, Cambridge University Press, USA, 2010.

RECOMMENDED ONLINE COURSE:

1. https://onlinecourses.nptel.ac.in/noc21_me44/preview

L: 45 TOTAL: 45 PERIODS

Course Code	ROBOTICS AND AUTOMATION	L	T	P	E	C
23EE36E		3	0	0	0	3

COURSE OUTCOMES

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

Theory Component:

CO 1: Demonstrate the fundamental elements of Robots
CO 2: Develop homogeneous transformation matrix for robot kinematics.
CO 3: Illustrate the differential motion and velocity using Jacobian matrix
CO 4: Analyse the mathematical model of the robot with dynamic equation
CO 5: Describe the role of image processing and vision system for an automation of robot.

CO1: Demonstrate the fundamental elements of Robots **L:9**

Robotics –Robot Characteristics – Classification - Actuators: Electric, Hydraulic, Pneumatic - Sensors: Position - velocity - acceleration - Torque sensors-tactile and touch sensors – DOF-Robot joints coordinates- Reference frame - work space

CO 2: Develop homogeneous transformation matrix for robot kinematics **L:9**

Robot Mechanism - Matrix representation - Manipulator kinematics - affixing frames to links -homogenous transformation - Forward and inverse kinematics – position and orientation –Roll, Pitch, yaw – Euler angles - degeneracy and dexterity.

CO 3: Illustrate the differential motion and velocity using Jacobian matrix **L:9**

DH representation - differential motion of frames – Interpretation of differential change - calculation of Jacobian- differential operator - Inverse Jacobian - Robots in industry: Robotic Arm.

CO 4: Analyse the mathematical model of the robot with dynamic equation

Lagrangian mechanics-dynamic equations-static force analysis– Inverse Kinematics - solution and programming– Basics of Trajectory planning - Motion control systems – Robot actuation and control – Case studies: material handling - pick and place - spot welding – spray coating. **L:9**

CO 5: Describe the role of image processing and vision system for an automation of robot. **L:9**

2D and 3D images – representation-noise and edges convolution masks-Processing techniques-noise reduction - edge detection - segmentation- Image analysis and object recognition - Case studies: Navigation of robot with obstacles.

TEXT BOOKS:

1. Saeed B. Niku, "Introduction to Robotics: analysis, Control, applications", 3rd Edition, Pearson Education, 2020
2. MikellP.Groover, "Industrial Robotics: Technology Programming and Applications", 2nd Edition, Tata Mcgraw Hill, 2012.

REFERENCES:

1. R.K. Mittal and I J Nagrath, "Robotics and Control", Tata McGraw Hill, 4th Reprint, 2005.
2. Fu, Gonzalez and Lee McGraw hill, "Robotics", International TATA McGraw Hill, 2008.
3. R.D. Klafter, TA Chmielewski and Michael Negin, "Robotic Engineering, an Integrated Approach", Prentice Hall of India, 2003.
4. B.K.Ghosh, Control in Robotics and Automation: Sensor Based Integration, Allied Publishers, Chennai, 1999.
5. RamachandranNagarajan, "Introduction to industrial robotics" Pearson publication 2016.
6. Mark W. Spong, Seth Hutchinson, M.Vidyasagar "Robot Dynamics and Control", Wiley publication 2004.

RECOMMENDED ONLINE COURSE (s)

1. https://onlinecourses.nptel.ac.in/noc22_me41/preview
2. https://onlinecourses.nptel.ac.in/noc21_me76/preview
3. https://onlinecourses.nptel.ac.in/noc21_me108/preview

L: 45; TOTAL: 45 PERIODS

Course Code	MEMS AND NEMS	L	T	P	E	C
23EE37E		3	0	0	0	3

COURSE OUTCOMES

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

Theory Component

CO1: Utilize microscaling law and material properties for the design of sensors and actuators.
CO2: Illustrate the operation of mechanical MEMS sensors and actuators
CO3: Demonstrate the unique features of thermal MEMS sensors and actuators.
CO4: Show the latest developments in MEMS for critical designs.
CO5: Demonstrate the applications of MEMS and NEMS technology in industries.

CO1: Describe microscale systems and its properties as sensors and actuators. **L:9**

MEMS – Micro sensors – Micro actuators – Scaling laws – Mechanical – Electrical – Thermal – Properties of Materials – System On a Chip (SOC) – Modelling Hybrid Systems – Micromachining process - Application specific integrated circuits (ASIC).

CO2: Explain the operation of mechanical MEMS sensors and actuators **L:9**

Beam and Cantilever – Micro plates – Capacitive effects – Piezo electric sensors and actuators – Pressure measurement by microphone - Shear mode piezo actuators – Gripping piezo actuators - MEMS gyroscope and accelerometers

CO3: Illustrate the features of thermal MEMS sensors and actuators **L:9**

Micro machined Thermocouple Probe – Peltier Effect Heat pumps – Thermal Flow sensor – MEMS Thermo vessels – Shape Memory Alloy – Thermally activated MEMS relay – Micro spring Thermal Actuator.

CO4:Comprehend the latest development in MEMS for critical designs **L:9**

MOEMS technology – Micro mirrors – Digital Micro mirror Device (DMD) – Magnetic materials for MEMS – Magnetic MEMS sensor – Mag MEMS actuator – Bidirectional Micro actuator – RFMEMS – MEMS switches – Resonator.

CO5:Demonstrate the application of MEMS and NEMS technology in industries **L:9**

Nanomaterials – Fullerenes – Carbon Nanotube (CNT) – Applications of CNT – Analytical and computational Modelling – Multiscale concepts and methods – Multi-engineering Integration - Application of MEMS in the automotive and biomedical industry

TEXT BOOKS:

1. Nitaigour Premchand Mahalik, “MEMS”, Tata McGraw-Hill Publishing Company Limited, 2013.
2. Sergey Edward Lyshevski, “MEMS and NEMS: Systems, Devices, and Structures” CRC Press, 2007.

REFERENCES:

1. Tai Ran Hsu, “MEMS and Microsystems Design and Manufacture”, Tata Mc-Graw Hill Private Limited, 2008.
2. James JAllen, ―Micro Electro Mechanical System Design CRC Press-Taylor & Francis‖, New York, 2005.
3. Mohamed Gad–el–Hak,” The MEMS Handbook”, CRC press Baco Raton, 2006.
4. Chang Liu, “Foundations of MEMS”, Pearson Education India Limited, 2012.

L: 45 TOTAL: 45 PERIODS

Course Code	BIG DATA ANALYTICS FOR SMART GRID	L	T	P	E	C
23EE38E		3	0	0	0	3

COURSE OUTCOMES

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

Theory Component

CO1: Explain the need, scope, and challenges of data analytics in modern Smart Grid systems

CO2: Identify and evaluate intelligent data acquisition devices and communication technologies used in Smart Grids

CO3: Apply Data Science Principles and Big Data Analytics tools to Process and Analyze Smart Grid datasets.

CO4: Develop and implement conventional and advanced machine learning models for smart grid applications.

CO5: Analyze real-world Smart Grid case studies and design cloud/edge-based data analytics solutions.

CO1: Explain the need, scope, and challenges of data analytics in modern Smart Grid systems **L:9**

Introduction to Smart Grids and Digitalization-Need for Data Analytics in Power Systems-Role of Data in Grid Stability, Reliability, and Efficiency-Types of Smart Grid Data (load, voltage, phasor, outage, renewable) - Challenges in Data Handling: Volume, Velocity, Variety, Veracity-Importance of Cyber-security and Data Quality)

CO2: Identify and evaluate Intelligent data acquisition devices and communication technologies used in Smart Grids **L:9**

Smart Meters and Advanced Metering Infrastructure (AMI)-PMUs, Micro-PMUs, IEDs, RTUs-SCADA, Synchro phasor Systems-IoT Sensors and Edge Devices-Communication Standards & Protocols: IEC 61850, DNP3, Modbus, MQTT-Data Acquisition Architecture for Modern Utilities

CO3: Apply Data Science Principles and Big Data Analytics tools to Process and Analyze Smart Grid datasets. **L:9**

Fundamentals of Data Science in Smart Grid Analytics-Data Cleaning, Normalization, Missing Data Handling-Feature Extraction for Grid Applications-Time-Series Analysis for Load, PV, Wind, and EV Profiles-Big Data Platforms: Hadoop, Spark, HDFS-Data Storage: SQL, NoSQL, Time-Series Databases-Data Visualization Tools for Grid Analytics.

CO4: Develop and implement conventional and advanced machine learning models for smart grid applications. **L:9**

Conventional ML Algorithms: Linear/Logistic Regression-KNN, Decision Trees, Random Forest-Clustering Methods: K-means-Advanced ML Algorithms: ANN, CNN, LSTM-Reinforcement Learning Basics. Applications in Smart Grid: Load and Renewable Forecasting-Fault Detection and Condition Monitoring-Energy Theft Detection-EV Charging Optimization-DER (Solar / Wind / Battery) Analytics.

CO5: Analyze real-world Smart Grid case studies and design cloud/edge-based data **L:9**

analytics solutions.

Case Studies in Big Data–Driven Smart Grid Operation-Load Forecasting-Demand Response-Outage Management and Fault Prediction-Renewable Variability Forecasting-Grid Asset Health Monitoring-Cloud Analytics Platforms (AWS, Azure, and Google Cloud)-Edge Computing Architectures for Real-Time Analytics-Edge Vs Cloud: Latency, Security, Scalability-IoT Gateways and Distributed Analytics-Design of Data Pipelines for Smart Grid Applications.

TEXT BOOKS:

1. James Momoh, "Smart Grid: Fundamentals of Design and Analysis", Wiley IEEE Press, 1st Edition, 2012.
2. Chakra borty, Big Data Analytics for Smart Grid Systems, Springer, 2018.

REFERENCES:

1. SK. D. Jones, "Python for Data Analysis", 3rd Edition O'Reilly Media, 2022.
2. Stuart Borlase, "Smart Grid: Infrastructure, Technology and Solutions", CRC Press, 2nd Edition, 2018.
3. Andreas C. Mueller & Sarah Guido, "Introduction to Machine Learning with Python", O'Reilly Media, Inc.-2017.

L: 45 TOTAL: 45 PERIODS

Course Code	**POWER QUALITY**	**L**	**T**	**P**	**E**	**C**
23EE39E		**3**	**0**	**0**	**0**	**3**

COURSE OUTCOMES

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

Theory Component

CO1: Outline power quality parameters, voltage variations, and standards governing electric power systems.
CO2: Classify single-phase and three-phase systems based on power quality issues.
CO3: Identify causes of voltage sags and summarize methods to reduce their effects.
CO4: Identify the need for power quality monitoring and power quality measurements.
CO5: Summarize distributed generation impacts and classify methods to improve power quality.

CO1: Outline power quality parameters, voltage variations, and standards governing electric power systems. **L:9**

Definition and Characterization of Electric Power Quality – Voltage Quality – Terms and Definitions – Classes of Power Quality Problems – Transients – Short and Long Duration Voltage Variations – Voltage Imbalance – Waveform Distortion – Voltage Fluctuations – Power Frequency Variation – Power Acceptability Curves (CBEMA Curve) – International standards of power quality: IEEE, IEC, ANSI, EN, UL

CO2: Classify single-phase and three-phase systems based on power quality issues. **L:9**

Analysis of single-phase and three-phase systems under power quality considerations – Single phase sinusoidal and non-sinusoidal sources supplying linear and nonlinear loads – Balanced and unbalanced three phase systems – Unbalanced and distorted sources feeding nonlinear loads – Concept of power factor and its impact on power quality –

Three-phase three-wire and four-wire systems.

CO3: Identify causes of voltage sags and summarize methods to reduce their effects.

Sources and types of voltage sags and interruptions – Estimation of sag severity and performance analysis – Mitigation using series compensators, static transfer switches, and protective devices. Thevenin's equivalent source – Analysis of faulted conditions – Voltage sag due to induction motor starting – Methods to minimize sag effects and ensure supply reliability.

CO4: Identify the need for power quality monitoring and power quality measurements. **L:9**

Monitoring considerations; Power quality measurement equipment - Assessment of power quality measurement data - Application of intelligent systems - Power quality monitoring standards. Analysis of unbalance - Compensator design - Mitigation of harmonics - Passive filters, Active filters – DSTATCOM - Dynamic Voltage Restorer (DVR).

CO5: Summarize distributed generation impacts and classify methods to improve power quality **L:9**

Introduction to Distributed Generation - Interface to the Utility System - Operating Conflicts -Interconnection Standards - Monitoring Considerations - Power Quality Measurement Equipment - Harmonics Analysis - Flicker Analysis - Voltage Sag/Swell and Interruption Monitoring - Disturbance Event Analysis

TEXT BOOKS:

1. Mishra, Mahesh Kumar, Power Quality in Power Distribution Systems: Concepts and Applications. CRC Press, 2024.
2. Roger C. Dugan, Mark F. McGranaghan, Surya Santoso, "Electrical Power System Quality", Tata Mcgraw-Hill, New Delhi, 2012.

REFERENCES:

1. Angelo Baggini, "Handbook of Power Quality", John Wiley & Sons Ltd, 2008.
2. Math H.J. Bollen, "Understanding Power Quality Problems: Voltage Sags and Interruptions", IEEE Press, New York, 2000.
3. J. Arrillaga, N.R. Watson and S. Chen, "Power System Quality Assessment", John Wiley & Sons Ltd., 2000.
4. Bhim Singh, Ambrish Chandra and Kamal Al-Haddad, "Power Quality: Problems and Mitigation Technique", Wiley Publications, 2015.
5. Arindam Ghosh and Gerard Ledwich, "Power Quality Enhancement Using Custom Power Devices", Kluwer Academic Publishers, 2012.
6. Sankaran C, "Power Quality", CRC Press (Special Indian Edition) 2009.

L: 45 TOTAL: 45 PERIODS

Course Code	**ENERGY AUDITING AND CONSERVATION**	**L**	**T**	**P**	**E**	**C**
23EE40E		**3**	**0**	**0**	**0**	**3**

COURSE OUTCOMES

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

Theory Component

CO1: Summarize the fundamental concepts of modern energy conservation and management systems.

CO2: Illustrate the process and tools used in modern energy auditing.

CO3: Outline various energy efficiency practices and technologies in industrial and commercial sectors.

CO4: Interpret the principles of intelligent and energy-efficient lighting systems.

CO5: Identify the energy conservation methods used in renewable-based power generation, transmission, and smart grids.

CO1: Summarize the fundamental concepts of modern energy conservation and management systems. **L:9**

Global and Indian energy scenario – current trends and challenges - Role of Energy Managers and Energy Auditors in the digital era - Energy management systems (EnMS) – ISO 50001:2023 framework - Concepts of sustainability and carbon neutrality - Energy performance indicators (EnPIs) and benchmarking - Integration of IoT and AI in energy management systems - Economic and environmental impact of energy conservation programs

CO2: Illustrate the process and tools used in modern energy auditing. **L:9**

Types and objectives of energy audit – overview of modern practices - Detailed methodology: Pre-audit, audit, post-audit with digital data collection - Use of data loggers, smart meters, and cloud-based analytics - Preparation and presentation of energy audit report - Energy performance contracting (EPC) and ESCO model - Government policies, IE rules, and Electricity (Amendment) Act 2022 - Case studies: Digital energy audits in industries and buildings

CO3: Outline various energy efficiency practices and technologies in industrial and commercial sectors.

Modern approaches to supply and demand side management - Real-time power factor correction using microprocessor-based systems - Smart transformers – monitoring and efficiency improvement - Energy-efficient motor systems: IE3 and IE4 standards - Variable frequency drives (VFDs) and soft starters for industrial automation - Predictive maintenance using condition monitoring and IoT - Case studies: Industry 4.0-based energy optimization

CO4: Interpret the principles of intelligent and energy-efficient lighting systems. **L:9**

Modern lighting technologies – LED, OLED, and solid-state lighting - Smart lighting controls – sensors, dimmers, daylight harvesting, IoT-based systems - Lighting automation and building integration - Renewable-powered lighting systems - Lighting design standards and simulation tools - Energy auditing and retrofit practices – case studies.

CO5: Identify the energy conservation methods used in renewable-based power generation, transmission, and smart grids **L:9**

Renewable energy integration – solar, wind, and hybrid systems - Co-generation and efficient power generation methods - Demand side management and load control techniques - Methods to reduce transmission and distribution (T&D) losses - Energy-efficient transformers and distribution systems - Power quality improvement and monitoring basics - Energy storage systems for reliability and efficiency.

TEXT BOOKS:

1. Albert Thumann and D. Paul Mehta, Handbook of Energy Engineering, CRC Press, 2021.
2. Abbi. Y.P and Shashank Jain, "Handbook on Energy Audit and Environment Management", the Energy and Resources Institute, 2015.

REFERENCES:

1. D. Yogi Goswami, Frank Kreith, "Energy Management and Conservation Handbook", CRC Press, 2nd edition, 2016.
2. Energy Efficiency in Electrical Utilities, Second Edition 2005, Bureau of Energy Efficiency, Ministry of Power, India.
3. Marguerite A. H Ruffner, Yacov Y. Haimes, "Energy Auditing and Conservation: Methods, Measurements, Management, and Case Studies", Taylor and Francis, 1980.
4. Energy management handbook, John Wiley and Sons – Wayne C. Turner, 2006

L: 45 TOTAL: 45 PERIODS

Course Code	ELECTRICAL SAFETY, OPERATIONS AND REGULATIONS	L	T	P	E	C
23EE41E		3	0	0	0	3

COURSE OUTCOMES

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

Theory Component

CO1: summarize the basics of electricity and general tools
CO2: Infer the power system components and grid management
CO3: Examine the parts of transformers and substation equipment.
CO4: Utilize different Earthing and Protective methods
CO5: Outline the different Electrical safety rules and Disaster management

CO1: summarize the basics of electricity and general tools **L:9**

Basics of Electricity: Introduction-Current, Voltage, Resistance-Power, Energy and Efficiency- Inductance, Capacitance and Impedance- Three types of electrical load-DC and AC Voltage-Current-Active and reactive Power- Power factor-Exposure to general tools and tackles: Introduction- Precautions in Handling Tools – Different types of tools and their use.

CO2: Infer the power system components and grid management **L:9**

Power system Overview :Introduction-Component Description-Structure of power system-Grid Management-Objectives of Grid Management-Quality of Electric Supply-Power distribution System-Overhead distribution system-Basic Elements-Performance of Distribution system-Power Cables

CO3: Examine the parts of transformers and substation equipment. **L:9**

Transformer: Introduction-Principle of operation- Transformer Selection-Classification-Constructional details-Reasons for transformer Failures- Transformers Testing-Enhancing Transformer Life and Efficiency-Substation Equipment:Introduction-66-33/11 KV Substation Equipment-11/0.4 KV Substation Equipment-O&M Practices for Substation Equipment and Distribution Lines.

CO4: Utilize different Earthing and Protective methods **L:9**

Earthing: Importance of Earthing-Classification-Line and Pole Earthing-Purpose of earthing-Guidelines for Earthing Arrangements-Measurement of Earth Resistance, Standards and their values-Maintenance - Protection: Types - Objectives -Equipment for system Protection-Functional Requirements of the Relays-System Protection Concepts-Distribution System Protection-Substation Protection-Instrument Transformers.

CO5:Outline the different Electrical safety rules and Disaster management **L:9**

Electrical safety- Safety Elements - Standards- Purpose of Electrical Safety Equipment, Personal Safety and Preventive Measures-Indian electricity rules (IE rules) related to safety-Accident Prevention-First aid-Golden Rules of the First Aid

Disaster management-Causes of Disaster in Power Sector-Objectives of Disaster Management.

TEXT BOOKS:

1. K. Mehta & Rohit Mehta, Basic Electrical Engineering, S. Chand Publishing, Revised Edition, 2019.
2. C. L. Wadhwa, Generation, Transmission and Distribution of Electrical Power, New Age International Publishers, 7th Edition, 2020.
3. H. Singh, Electrical Safety Practices, S. K. Kataria & Sons, 2022.

REFERENCES:

1. Electrical Safety Handbook, 4th Edition, McGraw-Hill Education, 2012.
2. Handbook of International Electrical Safety Practices, 1st Edition, Wiley-Scrivener, 2010.
3. J. B. Gupta, A Course in Electrical Power, S. K. Kataria & Sons, 2021.
4. B. L. Theraja & A. K. Theraja, A Textbook of Electrical Technology – Vol. II (AC & DC Machines), S. Chand Publishing, 24th Edition, 2012.
5. Sunil S. Rao, Practical Handbook on Electrical Wiring, Khanna Publishers, 19th Edition, 2020.

L: 45; TOTAL: 45 PERIODS

Course Code	ELECTRIC POWER STATIONS	L	T	P	E	C
23EE42E		3	0	0	0	3

COURSE OUTCOMES

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

Theory Component

CO1: Evaluate load and energy forecasting for short-term, mid-term, and long-term power system planning.
CO2: Classify and compare different types of power stations based on technical and economic aspects.
CO3: Explain the layout and working principles of steam and Nuclear power stations
CO4: Select appropriate turbine and generator units for hydro and renewable energy systems
CO5: Analyze electrical equipment, pollution standards in power plants.

CO1: Evaluate load and energy forecasting for short-term, mid-term, and long-term power system planning. **L:9**

Prediction of Load- Electrical Load Development - Types of Load - Load Requirements - Rural Electrification- Forecasting of Loads and Electrical Energy Requirements- Forecasting of Electrical energy used in India - Role of Artificial Intelligence and Machine Learning in Load Forecasting- Analysis of Short Term, Mid-Term and Long Term Load forecasting using AI and ML algorithm

CO2: Classify and compare different types of power stations based on technical and economic aspects. **L:9**

Choice of Power Stations and number of Generating Units- Types of Power Stations- Criteria for Choosing Type of Generation, Generator Units, and Optimal Number of Units - Load Duration Curve- Effect of Variable load on Power Plant Operation and Design- Cost of Electrical Energy- Depreciation - Effect of Load Factor on Cost per Kilowatt-hour.

CO3: Explain the layout and working principles of steam and Nuclear power stations **L:9**

Layout and working of Steam Station-Characteristics of Boiler, Steam Turbine and Turbo-Alternators - Instrumentation and Control- Cost of Steam Stations- Elements of Nuclear Power Stations - Types of Power Reactor- Location, Layout and Economics of Nuclear Power Station.

CO4: Select appropriate turbine and generator units for hydro and renewable energy systems **L:9**

Hydro-electric Stations-Preliminary Design: Size of Plant and Choice of Units-Characteristics of Turbine and Alternator-Power Station structure, layout and Control-Cost of Hydro - electric Stations. Preliminary design of Solar and Wind Electric System-Load sharing between conventional and non-conventional energy resources using AI and ML algorithm

CO5: Analyze electrical equipment, pollution standards in power plants **L:9**

Generators and Exciters-Power Transformer-Selection of Transformers-Circuit Breakers: Types and Characteristics- Selection and Specifications- Layout of Electrical Equipment-Trends in Power Plant Instrumentation Control-Pollution Control-Performance Standards: Air Pollution and Water Pollution Performance Standards. Case study: Analysis of Environmental Compliance - Case Study: Retrofitting Electrical and Pollution Control Systems in an Aging Power Plant

TEXT BOOKS:

1. R.K. Rajput, "A Textbook of Power Plant Engineering", Sixth edition, Lakshmi Publications Limited., 2021.
2. M.V. Deshpande, "Elements of Electrical Power Station Design", PHI Learning Pvt. Ltd., 2010.

REFERENCES:

1. Mohammad Mehdi Amiri, Hamdi Abdi, and Amjad Anvari-Moghaddam, "Artificial Intelligence in the Operation and Control of Digitalized Power Systems", Springer 2024.
2. R.S. Khurmi and J.K. Gupta, "Thermal Engineering", S. Chand Publishing-Latest Edition., 2022
3. Nag. P.K., "Power Plant Engineering", Sixth Edition, Tata McGraw–Hill Publishing Company Ltd., 2021.
4. S.N. Singh, "Electric Power Generation, Transmission and Distribution", 3rd Edition, PHI, Learning.,2020

L: 45; TOTAL: 45 PERIODS

Course Code	SUSTAINABLE POWER GENERATION SYSTEM	L	T	P	E	C
23EE43E		3	0	0	0	3

COURSE OUTCOMES

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

Theory Component

CO1: Explain the principles of sustainability and assess the environmental impact of conventional and renewable energy systems.

CO2: Analyze the working, components, and performance of solar photovoltaic and solar thermal systems.

CO3: Analyze the design, operation, and grid integration of wind energy systems.

CO4: Explain the functioning hydro power generation, hydrogen energy and fuel cell

CO5: Design hybrid renewable energy systems and their operation in distributed generation and micro grids.

CO1: Explain the principles of sustainability and assess the environmental impact of conventional and renewable energy systems **L:9**

Global and Indian scenario- Environmental impact of conventional Energy sources, Renewable Energy sources- Principle of sustainable development- Importance of sustainable development goal- Integration challenges of renewable energy to grid- Sustainable strategies for renewable energy integration into grid- Sustainable policy and planning strategies.

CO2: Analyze the working, components, and performance of solar thermal and solar photovoltaic systems. **L:9**

Fundamentals of Solar thermal energy conversion- solar thermal based power plant design and analysis (flat plate and concentrator),

Fundamentals of Solar photovoltaic energy conversion- Solar PV power plant design- Performance analysis of standalone and grid connected PV systems.

CO3: **Analyze the design, operation, and grid integration of wind energy systems** **L:9**

Basic principles of wind energy conversion- site selection considerations- basic components of Wind Energy Conversion System (WECS) - classification of WEC systems, wind energy collectors – horizontal axis machines and vertical axis machines- Induction Generator and Permanent Magnet Synchronous Generator (PMSG) - Grid integration of Wind Power.

CO4: Explain the functioning Hydro power generation, Hydrogen energy and fuel cells **L:9**

Introduction to hydro power plant, overview of micro, mini and small hydro power plants, Pumped storage, hydraulic turbines, Selection and design criteria of pumps and turbines - various routes of hydrogen generation- basic principle and design of different types of fuel cells and their applications

CO5: Design hybrid renewable energy systems and their operation in distributed generation and micro grids. **L:9**

Introduction to hybrid Energy storage system (Solar-Wind, Solar-Diesel) - DC and AC micro grid- Smart grid concept and Integration- Energy Storage Systems battery-flywheel-Super capacitor.

TEXT BOOKS:

1. J. Twidell, T. Weir, Renewable Energy Resources, Taylor and Francis, 4th Edition, 2021.
2. G.Boyle (Editor), Renewable Energy: Power for a Sustainable Future, Oxford University press, 3rd Edition, 2012.
3. B H Khan, Non conventional energy resources, McGraw Hill Education India 3rd editon, July, 2017

REFERENCES:

1. G. N. Tiwari, Solar Energy, Fundamentals, Design, Modeling and Applications, Narosa, 2002.
2. J.A.Duffie and W. A. Beckman, Solar Engineering of Thermal Processes, John Wiley, 4th Edition, 2013.
3. R. Gasch, J. Twele, Wind Power Plants: Fundamentals, Design, Construction and Operation, Springer, 2nd Edition, 2012.
4. https://onlinecourses.nptel.ac.in/noc23_ge47/preview
5. https://mnre.gov.in/en/annual-report/

L: 45 TOTAL: 45 PERIODS

Course Code	UTILIZATION OF ELECTRICAL ENERGY	L	T	P	E	C
23EE44E		3	0	0	0	3

COURSE OUTCOMES

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

Theory Component

CO1: Outline the various types of electric drives and their control used in industrial applications.
CO2: Apply concepts of electrical utilization for designing efficient systems for heating, welding, illumination.
CO3: Explain various methods of electric welding and heating systems.
CO4: Explain and compare various systems of track electrification
CO5: Analyze and differentiate various traction services using speed–time curves and Traction Control.

CO1: Outline the various types of electric drives and their control used in industrial applications **L:9**

Introduction to Electric drives- Parts of Electric drives- Transmission of power- Types of Electric drives- Factors governing the selection of Motors- Starting and Running Characteristics- Standard ratings of Motor- Selection of motor for different duty cycles- Selection of motor for specific application- Utilization of electric drives - Types of braking

CO2: Apply concepts of electrical utilization for designing efficient systems for Illumination. **L:9**

Radiant energy-Nature of light- Plane angle-Solid angle- Relation between plane angle and solid angle- Luminous flux- Luminous intensity,-Lumen, Candle power, Brightness or Luminance, Illumination, Uniform diffuse source- Mean candle power: horizontal, spherical, Hemi-spherical -Reduction factor- Lamp efficacy- Specific consumption- Utilization factor- Space-height ratio- Coefficient of utilization- Maintenance factor, Depreciation factor, Waste light factor, Absorption factor, Beam factor, Reflection factor, Glare- Design of lighting- Factory Lighting, Street Lighting and Flood Lighting.

CO3: Explain various methods of electric welding and heating systems **L:9**

Electric Welding: Introduction-Types of Electric welding- Resistance Welding- Laser welding - Arc welding and its types - Radiation Welding- Electric Welding Equipments

Electric Heating: Introduction- Advantages of Electric Heating- Classification of Electric Heating- Requirements of heating elements-Arc Furnaces.

CO4: Explain and compare various systems of track electrification **L:9**

System of Track Electrification- Description of various systems–Booster Transformer-Neutral Sectioning- Traction Machines- DC, 1-Phase AC-low frequency, high frequency, 3-Phase AC and Composite system - Current and voltage unbalance, production of harmonics and induction effects, comparison between AC and DC System.

CO5: Analyze and differentiate various traction services using speed–time curves and Traction Control. **L:9**

AC Electric Locomotive- Block diagram- Overhead equipment (OHE) - Pentagonal OHE-System of track electrification- catenary construction- Supporting

structure Current collection system- Current collection gear - Speed time curve for different services- Methods of starting and speed control of traction motors- Specific Energy consumption and Factors affecting effect.

TEXT BOOKS:

1. E. Openshaw Taylor and V.V.L.Rao, "Utilization of Electrical Energy", Universities press, 12th Edition 2009.
2. Tarlok Singh and M.A. Chaudhari "Utilization of Electrical Energy and Electric Drives And Electric Traction" 1st Edition 2013.

REFERENCES:

1. Generation, distribution and utilization of electrical energy by C.L. Wadhwa, 4th Edition 2011
2. R.K.RajPut , " Utilization of Electric power and Electric Traction, 1st Edition ,2007

L: 45; TOTAL: 45 PERIODS

Course Code	SMART GRID	L	T	P	E	C
23EE45E		3	0	0	0	3

COURSE OUTCOMES

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

Theory Component

CO1: Discuss the Evolution from Conventional Power Systems to Smart Grids
CO2: Describe the Concepts and Functions of Smart Meters and AMI
CO3:Explain the Concepts of Distributed Energy Resources, Storage Technologies, and Electric Vehicles
CO4: Interpret the Protection and Monitoring Techniques Used in Smart Grids
CO5:Summarize the Communication Framework, IoT Integration, and Cybersecurity Features of Smart Grids

CO1:Discuss the Evolution from Conventional Power Systems to Smart Grids **L:9**

Basics of power systems--Definition of smart grid-Need for smartgrid-Smart grid architectures-Standards and policies-Enablers of smart grid-Regulatory challenges-Smart-grid activities in India-Difference between conventional and Smart Grid.

CO2:Describe the Concepts and Functions of Smart Meters and AMI **L:9**

Introduction to Smart Meters- Advanced Metering infrastructure (AMI) drivers and benefits-AMI protocols and standards - IEEE 802 Series- IEC 62056- AMI needs in the smart grid- Demand Side Management-Substation Automation- Renewable Integration.

CO3: Explain the Concepts of distributed energy resources, storage technologies, and electric vehicle grid integration. **L:9**

Introduction to Distribution Energy Sources-Renewable Energy Technologies-Micro grids-Storage Technologies-Different types of energy storage technologies-Analytical modelling of energy storage devices-Optimal sizing and siting of storages-Battery management system (BMS)-Electric Vehicles and plug–in hybrids-Grid to vehicle and Vehicle to Grid.

CO4:Interpret the Protection and Monitoring Techniques Used in Smart Grids **L:9**

Introduction to Wide area Monitoring Systems-Phasor Estimation- Phasor Measurement Unit-Digital Relays for Smart Grid Protection-Islanding Detection Techniques- Smart Grid Protection- Operation and Control of AC micro grid, DC Micro grid and AC-DC micro grid.

CO5:Summarize the Communication Framework, IoT Integration, and Cybersecurity Features of Smart Grids **L:9**

Smart-grid control layer and elements-Network architectures-Local Area Network (LAN) - House AreaNetwork (HAN)-Wide Area Network (WAN)-Power line communications-Optical fibre Communication-IP-based systems-Applications of IoT in Smart Grid–Cloud Computing-Cyber security and resiliency.

TEXT BOOKS:

1. Borlase, S. Smart Grids: Advanced Technologies and Solutions. 2nd Edition, CRC Press, 2018.
2. Momoh, J. A. Smart Grid: Fundamentals of Design and Analysis. 1st Edition, Wiley, IEEE Press, 2012.
3. Keyhani, A., & Marwali, M. Smart Power Grids. 1st Edition, Springer, 2012.

REFERENCES:

1. Hatziargyriou, N. Microgrids: Architectures and Control. 1st Edition, Wiley-IEEE Press, 2014.
2. Phadke, A. G., & Thorp, J. S. Computer Relaying for Power Systems. 2nd Edition, Wiley, 2009.
3. Masters, G. M. Renewable and Efficient Electric Power Systems. 3rd Edition, Wiley-IEEE Press, 2023.
4. Keyhani, A., & Marwali, M. Smart Power Grids. 1st Edition, Springer, 2012.

L: 45; TOTAL: 45 PERIODS

Course Code	EMBEDDED SYSTEMS	L	T	P	E	C
23EE46E		3	0	0	0	3

COURSE OUTCOMES

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

Theory Component

CO1: Explain the architecture and basic components of embedded systems.
CO2: Compare and select communication interface, memory and IO devices.
CO3: Analyze HW/SW co-design approaches for data-flow embedded systems.
CO4: Apply the Embedded Development Life Cycle (EDLC) to document embedded application CO5: Explain the key concepts of RTOS and summarize processor trends.

CO1: Explain the architecture and basic components of embedded systems. **L:9**

Introduction – purpose of embedded systems –Von-Neumann architecture – Harvard architecture– characteristics and quality attributes–classifications and its types – hardware components – software components – core of embedded systems–

guidelines for PCB layout–selection process of microcontroller–Application areas.

CO2: Compare and select communication interface, memory and IO devices. **L:9**

Communication interfaces: UART, RS232, RS485, SPI, I2C, OneWire, CAN, USB, FireWire, Infrared – Bluetooth, WiFi, ZigBee – memory devices – direct memory access – I/O sub system –multilevel bus architecture – reset circuitry, brown out protection circuit, watch dog timer, oscillator unit, real time clock –IO Addressing – Port and bus based I/O – Memory mapped I/O and standard I/O.

CO3: Analyze HW/SW co-design approaches for data-flow embedded systems. **L:9**

Fundamental issues in HW/SW Co design – tools for single processor architectures – multi processor architectures – Co-design tools – testing in embedded systems – design process models – computational models in embedded design – HW/SW partitioning problem – HW/SW mapping – HW sharing – Interfacing – scheduling – Functional Pipelining.

CO4: Apply Embedded Development Life Cycle to document embedded application **L:9**

Embedded product development life cycle – different phases of embedded development life cycle – prototyping/evolutionary model – case studies on (ARM LPC 2148) Washing machine– Medical monitoring systems –Automated vending machines – Autonomous car – Precision Agriculture.

CO5: Explain the key concepts of RTOS and summarize processor trends. **L:9**

RTOS fundamentals – type of operating systems – task process and trends – Development language trends – multiprocessing and multitasking – task scheduling – device drivers – decision of choosing an RTOS – non preemptive scheduling – preemptive scheduling –Processor trends in embedded system.

TEXT BOOKS:

1. K. V. Shibu, Introduction to Embedded Systems, 1st Edition, McGraw Hill Education (India) Pvt. Ltd., 2009.
2. Frank Vahid and Tony Givargis, Embedded System Design: A Unified Hardware/Software Introduction, 1st Edition, John Wiley & Sons, 2002.
3. Ralf Niemann, System Level Design with Reuse: A Practical Guide, 1st Edition, Springer-Verlag, Berlin Heidelberg, 2001.
4. Rajkamal, Embedded Systems: Architecture, Programming and Design, 3rd Edition, McGraw Hill Education (India) Pvt. Ltd., 2018.

REFERENCES:

1. Arnold S. Berger, Embedded System Design: An Introduction to Processes, Tools, and Techniques, 1st Edition, CMP Books/Elsevier, 2002.
2. Steve Heath, Embedded Systems Design, 2nd Edition, Newnes (Elsevier Science), 2003.
3. C.M.Krishna and Kang G.Shin, Real-Time Systems, 1st Edition, McGraw Hill International Editions, 1997.
4. S. T. Allworth, An Introduction to Real-Time Systems: Design to Networking with C/C++, 2nd Edition, Macmillan Education Ltd., 1992.
5. David E. Simon, An Embedded Software Primer, 1st Edition, Addison-Wesley Longman, 1999.

L: 45; TOTAL: 45 PERIODS

R-2023 B.E. EEE

ONE CREDIT COURSES

Course Code	ARDUINO AND ESP32 PROGRAMMING	L	T	P	E	C
23EE01L		0	0	2	0	1

COURSE OUTCOMES

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

Practical Component:

CO1: Interface IO devices such as sensors, actuators, displays, and communication modules using Arduino.
CO2: Design and develop embedded system-based applications robots using Arduino
CO3: Develop IoT-based systems using Node MCU ESP32 and mobile applications

LIST OF EXPERIMENTS

Experiment 1: LED and LCD Interfacing using Arduino

- **Objective:** To interface LEDs and alphanumeric LCD (16x2) with Arduino and display data.
- **Tasks:**
  - Interface 16x2 LCD in 4-bit mode.
  - Simulate using Proteus (optional).

Experiment 2: Analog and Digital I/O Interface using Arduino

- **Objective:** To read analog and digital inputs and control outputs accordingly.
- **Tasks:**
  - Use push buttons, switches as digital inputs.
  - Read analog input from a potentiometer.

Experiment 3: DC Motor Interfacing (Forward and Reverse)

- **Objective:** To control the direction and speed of a DC motor.
- **Tasks:**
  - Interface DC motor using L293D or L298N motor driver.
  - Control forward and reverse motion using digital logic.

Experiment 4: Ultrasonic Distance Sensor Interfacing

- **Objective:** To measure distance using HC-SR04 ultrasonic sensor.
- **Tasks:**
  - Display distance in cm on Serial Monitor or LCD.
  - Use measured distance to trigger LED or buzzer.

Experiment 5: Servo/Stepper Motor Interfacing

- **Objective:** To control angle or position using servo or stepper motors.
- **Tasks:**
  - Interface servo motor using PWM.
  - Interface stepper motor using ULN2003 or A4988 driver.

Experiment 6: GSM/GPS Interfacing using Arduino

- **Objective:** To send SMS and receive location data using GSM/GPS modules.
- **Tasks:**
  - Send and receive SMS using SIM800L/SIM900 module.
  - Extract and display GPS coordinates using NEO-6M GPS module.

Experiment 7: Bluetooth Interfacing with Arduino

- **Objective:** To communicate wirelessly with Arduino using a mobile app.
- **Tasks:**
  - Send commands from Android phone to control LEDs or motors.
  - Receive data back from Arduino to phone.

Experiment 8: Simple Mobile Application Development

- **Objective:** To create a mobile app to control Arduino hardware.
- **Tasks:**
  - Design a GUI using MIT App Inventor.
  - Use Bluetooth blocks to send data to Arduino.
  - Implement features like button press to turn on LED or move robot.

Experiment 9: Obstacle Avoidance Robot using Arduino

- **Objective:** To build a robot that avoids obstacles using sensors.
- **Tasks:**
  - Interface ultrasonic sensor and DC motors.
  - Develop algorithm to detect and avoid obstacles.
  - Assemble and test the mobile robot chassis.

Experiment 10: IoT Application using ESP32

- **Objective:** To build a basic IoT project using NodeMCU.
- **Tasks:**
  - Interface sensor (e.g., DHT11, LDR) to NodeMCU.
  - Upload data to a cloud server (ThingSpeak/Firebase).
  - Monitor data via smartphone or web browser.

P: 30; TOTAL: 30 PERIODS

REFERENCES:

1. Jeremy Blum, "Exploring Arduino: Tools and Techniques for Engineering Wizardry", Wiley Publication, 2nd Edition, 2019.
2. John-David Warren, Josh Adams, and Harald Molle, "Arduino Robotics", Apress Publication, 1st Edition, 2011.
3. Derek Walter and Mark Sherman, "Learning MIT App Inventor: A Hands-On Guide to Building Your Own Android Apps", Que Publishing, 1st Edition, 2014.
4. Marco Schwartz, "Internet of Things with the ESP8266", Packt Publishing, 1st Edition, 2016.

Course Code	PCB DESIGN AND FABRICATION	L	T	P	E	C
23EE02L		0	0	2	0	1

COURSE OUTCOMES

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

Practical Component:

CO1: Design and simulate electronic circuits using CAD software for schematic and PCB layout creation.
CO2: Apply PCB design rules to develop single-layer and double-layer PCBs including footprint management and rule checking.
CO3: Generate industry-standard fabrication files such as Gerber and drill files for PCB manufacturing.
CO4: Demonstrate the complete PCB fabrication process including artwork transfer, etching, component assembly, and testing.

1: Schematic Design of Basic Electronic Circuits

- Objective: Learn to create schematics using CAD software.
- Tasks: Design circuits like voltage divider, transistor switch, logic gates.

2: Component Footprint Assignment and Library Management

- Objective: Assign footprints to components and manage libraries.
- Tasks: Use default and custom libraries, link schematic symbols to footprints.

3: PCB Layout Design – Single-Layer PCB

- Objective: Convert schematic to PCB and route tracks for a simple circuit.
- Tasks: Layout for Simple circuit, single-sided routing.

4: PCB Layout Design – Double-Layer PCB

- Objective: Practice using top and bottom layers.
- Tasks: Design a double-layer PCB for a circuit given.

5: Design Rules and Electrical Rule Check (DRC/ERC)

- Objective: Validate PCB design for fabrication errors.
- Tasks: Run and interpret DRC/ERC in the software

6: Power Supply Circuit Design

- Objective: Design and simulate a regulated DC power supply.
- Tasks: Complete Linear mode power supply schematic, layout, and PCB design.

7: Microcontroller-Based Circuit Design

- Objective: Design PCB for a simple Arduino/AVR-based circuit.
- Tasks: Interface LED or sensor with ATmega328/Arduino.

8: Generating Gerber Files

- Objective: Prepare files for fabrication.
- Tasks: Generate Gerber, drill, and pick-and-place files from PCB layout.

9: PCB Fabrication (Artwork Printing & Etching)

- Objective: Understand the fabrication process (manual or through service).
- Tasks: Export design to PDF, print on transparency, etch using ferric chloride.

10: PCB Assembly and Testing

- Objective: Populate and test fabricated PCB.
- Tasks: Solder components and verify the working of the designed circuit.

P: 30; TOTAL: 30 PERIODS

REFERENCES:

1. Jan Axelsen, "Printed Circuit Board Design Using AutoCAD", Newnes Publication, 1st Edition, 1997.
2. R.S. Khandpur, "Printed Circuit Boards: Design, Fabrication, Assembly and Testing", Tata McGraw-Hill Education, 1st Edition, 2005.
3. K.C. Johar and R.K. Anand, "Electronic Circuit Design", Tata McGraw-Hill Education, 1st Edition, 2010.
4. Simon Monk, "Make Your Own PCBs with EAGLE: From Schematic Designs to Finished Boards", Maker Media, 1st Edition, 2013.

Course Code	ARM ARCHITECTURE AND MICROPYTHON	L	T	P	E	C
23EE03L		0	0	2	0	1

COURSE OUTCOMES

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

Practical Component

CO1: Write and upload micropython scripts in RP2040 controller.
CO2: Build end- to- end data logging system by pushing JSON formatted data to cloud

Introduction to Micro python –Data Types & Variables–Control Structures–Loops - Functions & Modules – List and Tuples –micropython error Handling–IDE Installation & Configuration–REPL Interaction–Basic Script Writing–Script File Management – RP2040 ARM CortexM0+ architecture – Pico and Pico W pin diagram and its functions –Analog and digital Input Output Interfacing with sensors and actuators –PWM Control and configurations – Communication protocols UART, I2C, SPI –REPL to inspect variables–Wi-Fi connection on Pico W – HTTP basics – urequests and get – HTTP POST to firebase–Firebase real time database– authentication &security – API key – Environmental Sensor Integration–JSON Formatting & Transmission–Data Logging Workflow–Logging Loop–Local Backup–Visualization & Mini Project. **P:30**

P: 30; TOTAL: 30 PERIODS

REFERENCES:

1. Python for Microcontrollers: Getting Started with MicroPython, Donald Norris, 1st Edition, McGraw-Hill Education, 2020
2. Getting Started with MicroPython: Programming and Electronics with the ESP32 and ESP8266, Miguel Grinberg, 1st Edition, O'Reilly Media, 2021.
3. The Official Raspberry Pi Pico Guide: Raspberry Pi Pico & Pico W, Raspberry Pi Foundation, 2nd Edition, Raspberry Pi Press, 2023.
4. Programming the Raspberry Pi Pico/W with MicroPython, Simon Monk, 1st Edition, MonkMakes Publishing, 2023.
5. https://docs.micropython.org
6. https://www.raspberrypi.com/documentation/microcontrollers/
7. https://wokwi.com/

Course Code	THERMAL POWER PLANTS – EQUIPMENTS, OPERATION AND CONTROL	L	T	P	E	C
23EE04L		1	0	0	0	1

COURSE OUTCOMES

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

Theory Component

CO1: Illustrate the layout, working principles, and components of steam and combined cycle power plants

CO2: Analyze the role of instrumentation and control systems in the operation, monitoring, and automation of thermal power plants.

CO1: Illustrate the layout, working principles, and components of steam and combined cycle power plants **L:8**

Steam Power Plants: Rankine cycle - improvisations, Layout of modern coal power plant, Super Critical Boilers, Boiler components, coal storage, coal handling systems, feeding and burning of pulverized fuel, ash handling systems, dust collection-mechanical dust collector and electrostatic precipitator, Draught system, Turbines, Condensers and electrical equipments.

Combined Cycle Power Plants: Components of Gas Turbine power plants. Combined Cycle Power Plants. Integrated Gasifier based Combined Cycle systems.

CO2: Analyze the role of instrumentation and control systems in the operation, monitoring, and automation of thermal power plants. **L:7**

Instrumentation & Control: Plant Instrumentation, General & Special Instrumentation, centralized & automatic control equipment, types of controls. Operation, control and supervision of Boiler, Turbine and Alternator

L: 15; TOTAL: 15 PERIODS

REFERENCES:

1. Dipak K. Sarkar, Thermal Power Plant: Design and Operation, *Elsevier, 1st Edition, 2015.*
2. Swapan Basu and Ajay Kumar Debnath**,** Power Plant Instrumentation and Control Handbook: A Guide to Thermal Power Plants, Academic Press, 2nd Edition, 2019.
3. David Lindsley, John Grist, and Don Parker**,** Thermal Power Plant Control and Instrumentation: The Control of Boilers and HRSGs, IET (Institution of Engineering and Technology), 2nd Edition, 2018.
4. Meherwan P. Boyce**,** Handbook for Cogeneration and Combined Cycle Power Plants, ASME Press, 2nd Edition, 2011.
5. Rolf Kehlhofer**,** Combined-Cycle Gas & Steam Turbine Power Plants, Fairmont Press, 3rd Edition, 2009.
6. M.M. El-Wakil, Power Plant Technology, McGraw-Hill Education, Reprint Edition, 2017.

Course Code	NUCLEAR POWER PLANTS –EQUIPMENTS, OPERATION AND CONTROL	L	T	P	E	C
23EE05L		1	0	0	0	1

COURSE OUTCOMES

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

Theory Component

CO1: Explain the fundamentals of nuclear energy generation and its working principles
CO2: Examine the biological impacts of nuclear radiation

CO1: Explain the fundamentals of nuclear energy generation and its working principles **L:8**

Nuclear Power Industry Overview, drivers for nuclear energy as a power option, nuclear fuel cycle, Nuclear fission, nuclear chain reaction

Various types of nuclear power plants (NPP), features of a pressurised water reactor, aspects related to reliability and safety of a nuclear power plant, reactor control, reactor safety.

CO2: Examine the biological impacts of nuclear radiation **L:7**

Biological effects of radiation, various methods of radioactive waste disposal.

L: 15; TOTAL: 15 PERIODS

REFERENCES:

1. Raymond L. Murray, Nuclear Energy: An Introduction to the Concepts, Systems, and Applications of Nuclear Processes, 6th edition, Elsevier, Burlington, 2009.
2. P.K. Nag, Power Plant Engineering, 3rd edition, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2008.
3. A.W. Culp Jr., Principles of Energy Conversion, 2nd edition, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2000.

Course Code	QUALITY PRACTICES FOR SAFETY CRITICAL	L	T	P	E	C
23EE06L	INSTRUMENTATION SYSTEM	1	0	0	0	1

COURSE OUTCOMES

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

CO1: expose the students to requirement of standards and calibration techniques, safety and reliability mechanisms used in process industries.

CO2: impart knowledge about EMI and EMC problems in industrial measurements.

CO3: make the students to draw the specification of the industrial instruments and prepare the instrumentation project documents.

COURSE CONTENT:

Standards and Calibration: Introduction to standards and calibration of measuring instruments - Guidelines of enclosure design – IP standards.

EMI and EMC: Introduction - interference coupling mechanism - basics of circuit layout and grounding - concepts of interfaces - filtering and shielding - co-axial & twisted pair cable - electronic grounding.

Safety: Introduction - electrical hazards - hazardous areas and classification - nonhazardous areas – enclosures - NEMA types - fuses and circuit breakers. Protection methods: Purging - explosion proofing and intrinsic safety.

Reliability: Bathtub curve - reliability for series parallel systems - Mean Time To Failure (MTTF) - Mean Time To Repair (MTTR) - Mean Time Between Failures (MTBF) – availability - redundancy and stand by.

Specifications: Specification of instruments - preparation of project documentation - process flow sheet - instrument index sheet - instrument specifications sheet – panel drawing and specifications, instrument specifications - Project procedure - schedules, vendor drawing, tender documentation - selection of measurement method and control panels.

L: 15 TOTAL: 15 PERIODS

REFERENCES:

1. Noltingk B.E., Instrumentation Reference Book, Butterworth Heinemann, 2nd Edition, 1995.
2. Liptak B.G, Process Measurement and Analysis, Chilton Book Company, Radnor, Pennsylvania, 4th Edition, 2003.
3. Andrew W.G, Applied Instrumentation in Process Industries – A survey, Vol I & Vol II, Gulf Publishing Company, Houston, 2001
4. Patranabis D., Principles of Industrial Instrumentation, Tata McGraw Hill Publishing Company Limited, 3rd Edition, 2010.
5. Lawrence D. Goettsche, Maintenance of Instruments and Systems, International society of automation, 2nd Edition, 2005.
6. Henry W.Ott, Electromagnetic Compatibility Engineering, A John Wiley & Sons, INC., Publication, 2009

Course Code	HYDROGEN ENERGY AND FUEL CELLS	L	T	P	E	C
23EE07L		1	0	0	0	1

COURSE OUTCOMES

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

CO1: Understand and demonstrate the hydrogen production technologies, storage methods and strategies for transition to hydrogen economy.

CO2: Explain the concepts and characteristics of various types of fuel cell

CO3: Describe the application of fuel cells.

COURSE CONTENT:

Hydrogen Energy - Introduction to hydrogen economy, production, storage and transportation systems, hydrogen from fossil fuels, electrolysis of water, safety and environmental impacts, economics of transition to hydrogen systems. Fuel Cells - Concept, key components, physical and chemical phenomena in fuel cells, advantages and disadvantages, different types of fuel cells, characteristics. Fuel Cells - Application - Fuel cell usage for domestic power systems, large scale power generation, automobile and space.

L: 15 TOTAL: 15 PERIODS

REFERENCES:

1. Fuel cell Fundamentals, John Wiley and sons, Willey 3rd Edition, 2016.
2. Fuel cells: Principles and Applications, Viswanathan B and Aulice Scibioh, University Press, 2008
3. Tomorrow's Energy – Hydrogen Fuel Cells and the Prospects for Cleaner Planet, Peter Hoffman, MIT, 2002.
4. Hydrogen – A fuel for Automatic Engines, Prashukumar G P, ISTE.

Course Code	VLSI DESIGN LABORATORY	L	T	P	E	C
23EE08L		0	0	2	0	1

COURSE OUTCOMES

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

Practical Component

CO1: Write Verilog HDL code for VLSI system components, synthesize and implement the circuits in FPGAs.

CO2: Analyze the characteristics of CMOS Inverter and Differential Amplifier

CO3: To develop skill in verifying and analyzing processors at various abstraction levels.

LIST OF EXPERIMENTS

CO1: Write Verilog HDL code for VLSI system components, synthesize and implement the circuits in FPGAs.

Experimental analysis: Modelling: Design entry and simulation of combinational and sequential circuits - Design entry and simulation of finite state machines - Test bench creation and functional verification of combinational and sequential circuits

CO2: Analyze the characteristics of CMOS Inverterand Differential Amplifier.

Experimental analysis: Design and simulation of a CMOS inverter. Perform layout simulation and parasitic extraction - Schematic Entry and simulation of MOS differential amplifier, Determination of gain, bandwidth, output impedance and CMRR.

CO3: To develop skill in verifying and analyzing processors at various abstraction levels.

Synthesize and implement 8 8-bit general-purpose processor in Verilog- Synthesize and implement UART and USART communication protocol.

P: 30; TOTAL: 30 PERIODS

R-2023 B.E. EEE

OPEN ELECTIVE COURSES

Course Code	LINEAR ALGEBRA, MATHEMATICAL LOGIC AND SET THEORY	L	T	P	E	C
23SH01E		2	1	0	0	3

COURSE OUTCOMES:

Upon successfully completing the course, the students will be able to:

CO1: analyze concepts of vector spaces. (CDL 1)

CO2: measure the similarity between different datasets using Inner product spaces. (CDL 1)

CO3: decompose the matrix for computational convenience. (CDL 1)

CO4: illustrate the validity of the arguments. (CDL 1)

CO5**:** analyze the concepts of Sets, Relations and Functions. (CDL 1)

CO1: analyze concepts of vector spaces

Vector spaces – Subspaces – Linear combinations – linear span - Linear independence and linear dependence – Bases and dimensions. **L:6 T:3**

CO2: measure the similarity between different datasets using Inner product spaces

Linear transformation - Null spaces and ranges – Rank Nullity theorem - Matrix representation of a linear transformations - Inner product space - Norms - Orthonormal Vectors - Gram Schmidt orthogonalisation process**.** **L:6 T:3**

CO3: decompose the matrix for computational convenience

Generalized eigenvector - QR decomposition- generalized inverse - Singular value decomposition and applications – Pseudo Inverse . **L:6 T:3**

CO4: illustrate the validity of the arguments.

Propositional Logic – Equivalences and Implications – Normal forms – Predicate Calculus and Quantifiers - Rules of inference – Proof methods and Strategies - Forward Proof, Proof by Contradiction, Proof by Contraposition, Proof of Necessity and Sufficiency. **L:6 T:3**

CO5: analyze the concepts of Sets, Relations and Functions

Basic Definitions - Set operations – Laws of set theory – Relations – Properties of relations - Partial Ordering Relation - Equivalence Relation - Matrices of relations - Closure of relations – Functions – Bijective functions - Inverse and Compositions of functions. **L:6 T:3**

TEXT BOOKS

1. Kenneth H.Rosen, Discrete Mathematics and its Applications (with Combinatory and Graph Theory), Special Indian Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 8th Edition, 2021.
2. Bernard Kolman and David Hill, "Elementary Linear Algebra with Application" Pearson India, 9th Edition, 2019.
3. Erwin Kreyszig, "Advanced Engineering Mathematics", 10th Edition, Wiley India, 2017.

REFERENCES

1. Trembly J.P and Manohar.R. Discrete Mathematical Structures with Applications to Computer Science, 1st Edition, Tata McGraw-Hill Pub. Company Limited, New Delhi, 2017.
2. Friedberg, A.H., I nsel,A.J.and Spence, L., Elementary Linear Algebra, a matrix approach, 2nd Edition pearson Publication.
3. Raju.K.George and Abhijith Ajayakumar, A course in Linear Algebra, Springer, 2024.
4. Seymour Lipschutz Marc Lipson., "Linear Algebra" Schaum's Out lines series, 6th Edition, McGraw – Hill Education, 2018.

L : 30; T :15; TOTAL : 45 PERIODS

Course Code	LINEAR STRUCTURES AND	L	T	P	E	C
23SH02E	TRANSFORMATIONS	2	1	0	0	3

COURSE OUTCOMES:

Upon successfully completing the course, the students will be able to:

CO1: solve the linear system of equations. (CDL 1)

CO2: determine the dimension of vector spaces. (CDL 1)

CO3: find the orthonormal vectors using Inner product spaces. (CDL 1)

CO4: illustrate Jordan canonical form on a finite dimensional vector space. (CDL 1)

CO5:decompose the matrix using Generalized Eigen vectors for computation.(CDL 1)

CO 1: solve the linear system of equations **L:6**

General system of linear equations – Matrices– Echelon form of matrix- Solving linear systems- Consistency of a system of linear equations -LU factorization. **T:3**

CO2: determine the dimension of vector spaces

Vector spaces – Subspaces – Linear combinations – linear span - Linear independence and linear dependence – Bases and dimensions. **L:6 T:3**

CO3: find the orthonormal vectors using Inner product spaces

Linear transformation - Null spaces and ranges – Rank Nullity Theorem - Matrix representation of a lineartransformations - Inner product space - Norms - Orthonormal Vectors - Gram Schmidt orthogonalisation process. **L:6 T:3**

CO4: illustrate Jordan canonical form on a finite dimensional vector space

Generalized eigenvector- Chains- Canonical basis the minimum polynomial- - Algebraic and Geometric multiplicity of Eigen Values - Similar matrices-Modal matrix-Jordan canonical form. **L:6 T:3**

CO5: decompose the matrix using Generalized Eigen vectors for computation

Eigen-values using QR transformations – Generalized Inverse Eigen vectors – Canonical forms – Singular value decomposition and applications – Pseudo inverse **L:6 T:3**

TEXT BOOKS

1. Bernard Kolman and David Hill, "Elementary Linear Algebra with Application" Pearson India, 9th Edition 2019.
2. Seymour Lipschutz Marc Lipson., "Linear Algebra" Schaum's Out lines series, Six edition, McGraw – Hill Education, 2018.

REFERENCES

1. Friedberg, A.H., I nsel,A.J.and Spence, L., Elementary Linear Algebra, A Matrix Approach, 2nd Edition, Pearson 2019.
2. Jim Defranza. Daniel Gagiardi "Introduction to Linear Algebra with Applications" Waveland Pr Lnk, 2015.
3. Eggar.Goodaire "Linear Algebra Pure & Applied", World Sceintific, New Delhi, first edition, 2015.
4. Raju.K.George and Abhijith Ajayakumar, A course in Linear Algebra, Springer, 2024.

64.

L : 30; T :15; TOTAL : 45 PERIODS

Course Code		L	T	P	E	C
23SH03E	**NUMBER THEORY**	**2**	**1**	**0**	**0**	**3**

COURSE OUTCOMES:

Upon successfully completing the course, the students will be able to:

CO1: acquire the concepts of theory of numbers. (CDL 1)

CO2: apply the fundamental propositions to interpret solutions of congruence. (CDL 1)

CO3: find the primitive roots for the congruence. (CDL 1)

CO4: analyze the inter-relation between arithmetical functions. (CDL 1)

CO5: determine quadratic residues of congruence. (CDL 1)

CO1 : acquire the concepts of theory of numbers

Introduction – Divisibility- Greatest common divisor - Prime numbers - The fundamental theorem of arithmetic - The series of reciprocals of the primes - The Euclidean algorithm(without Proof) - The greatest common divisor of more than two numbers. **L:6 T:3**

CO2 : apply the fundamental propositions to interpret solutions of congruence

Congruence - Linear congruence - Euler-Fermat theorem - Polynomial congruence modulo p – Wilson's Theorem **L:6 T:3**

CO3: analyze the inter-relation between arithmetical functions.

The Mobius function μ(n) – The Euler Totient function φ(n)– A relation connecting φ and μ – A product formula for φ(n) – properties of φ(n) –Multiplicative functions– completely multiplicative function. **L:6 T:3**

CO4: determine quadratic residues of congruence

Quadratic Residues – Legendre's symbol and its properties – Evaluation of (-1|p) and (2|p) – Gauss lemma – The Quadratic Reciprocity law – Applications – The Jacobi symbol. **L:6 T:3**

CO5: implement the concepts of congruence in cryptography

Chinese remainder theorem - Applications of Chinese remainder theorem - Cryptography and its application – RSA algorithm and Rabin Cryptosystem. **L:6 T:3**

TEXT BOOKS

1. Tom M.Apostol, "Introduction to Analytic Number Theory", Springer International Edition, Narosa Publishing House, New Delhi, 2013.
2. G.A.Jones & J.M.Jones, "Elementary Number Theory", Springer publications, 2012.

REFERENCES

1. David M.Burton, "Elementary Number Theory", McGraw Hill, 7th Edition,2023
2. Joseph H.Silverman, "A Friendly Introduction to Number Theory", Pearson Education, 4th Edition, 2019.
3. Titu Andreesu, Gabriel Dospinescu, Oleg MushKarov, Number Theory: concepts and problems, Springer Science & Business Media, 2017.
4. S B Malik , "Basic Number Theory", S Chand publications, 2nd Edition, 2018

L : 30; T :15; TOTAL : 45 PERIODS

Course Code		L	T	P	E	C
23SH04E	**NUMERICAL ANALYSIS**	**2**	**1**	**0**	**0**	**3**

COURSE OUTCOMES:

Upon successfully completing the course, the students will be able to:

CO1: solve algebraic and transcendental equations using numerical methods. (CDL 1)

CO2: interpolate and approximate the polynomial of data. (CDL 1)

CO3: perform numerical differentiation and integration. (CDL 1)

CO4: find numerical solution of ordinary differential equation. (CDL 1)

CO5: classify and find numerical solution of partial differential equations. (CDL 1)

CO 1: solve algebraic and transcendental equations using numerical methods

Solutions of Algebraic linear equations Newton - Raphson Method, Fixed Point Iteration method - Solutions of algebraic simultaneous linear equations - Gauss Elimination –Gauss Seidel Methods. **L:6 T:3**

CO 2: interpolate and approximate the polynomial of data

Curve Fitting – Method of Least Squares – Fitting a Straight Line – Fitting a Second Degree Parabola - Finite differences - Newton's Forward & Backward Difference Formulae - Central Differences - Stirling's Formula - Lagrange's Formula. **L:6 T:3**

CO 3: perform numerical differentiation and integration

Derivatives using forward and backward difference Formulae - Trapezoidal rule - Simpson's rules - Double integration using Trapezoidal and Simpson's rules. **L:6 T:3**

CO 4: find numerical solution of ordinary differential equation

Taylor's Series Method - Euler's Method – Runge Kutta fourth order Method – Predictor - corrector Methods - Milne's Method - Finite difference for solving ordinary differential equation. **L:6 T:3**

CO 5: classify and find numerical solution of partial differential equations

Classification of Partial Differential Equations of second order - Finite difference solution of one dimensional heat equation by explicit and implicit methods (Crank Nichelson and Bender Schmidth methods) - One dimensional wave equation and two dimensional Laplace and Poisson equations. **L:6 T:3**

TEXT BOOKS

1. Grewal, B.S., "Numerical Methods in Engineering & Science: With Programs in C, C++ & MATLAB", 11th Edition, Khanna Publishers, New Delhi, 2014.
2. M.K.Jain, S.R.K.Iyengar, R.K.Jain "Numerical Methods for scientific and Engineering Computation", 6th Edition, New age International Publishers, 2019.
3. Erwin Kreyszig, Advanced Engineering Mathematics, 10th Edition, J. Wiley and Sons, 2023.

REFERENCES

1. Chapra, S. C and Canale, R. P. "Numerical Methods for Engineers", 8th Edition, Tata McGrawHill, New Delhi, 2021.
2. Saumyen Guha, Rajesh Srivastava "Numerical Methods: For Engineering and Science", Oxford University Press, New Delhi, 1st Edition with third impression, 2015.
3. K.Sankara Rao , "Numerical Methods For Scientists And Engineers", 5th Edition, New age International Publisher, 2018
4. Dr Chaitanya Kumar, Dr Harinderjit Kaur Chawla, Dr Indarpal Singh "A Textbook on Numerical Methods and Analysis" Sultan Chand and SonsPublisher, 2024

L : 30; T :15; TOTAL : 45 PERIODS

Course Code		L	T	P	E	C
23SH05E	**OPTIMIZATION TECHNIQUES**	2	1	0	0	3

COURSE OUTCOMES:

Upon successfully completing the course, the students will be able to:

CO1: find optimum solution of linear programming problem. (CDL 1)

CO2: determine the optimum schedule for assignment and transportation problems. (CDL 1)

CO3: acquire decision making in Pure and Mixed Strategies. (CDL 1)

CO4: analyze the network for optimal schedule. (CDL 1)

CO5: compute optimum solution of non-linear programming. (CDL 1)

CO1: find optimum solution of linear programming problem

Linear Programming Problem – Mathematical Formulation of Linear Programming Problems (LPP) – Graphical Solution Method - Canonical and Standard Forms of LPP - Simplex Method - Linear Programming using Artificial Variables - Two Phase Method. **L:6 T:3**

CO2:acquire decision making in Pure and Mixed Strategies

Basic Terms in Game Theory - Two-Person Zero-Sum Games - Maximin-Minimax Principal - Games without Saddle Points - Mixed Strategies-Pure and Mixed Strategies with Saddle Point- Mixed Strategy Problems by Arithmetic Method- Graphic Solution of $2 \times n$ and $m \times 2$ Games. **L:6 T:3**

CO3: analyze the network for optimal schedule

Development of Network Analysis - Network Analysis and Rules of Network Construction - Critical Path Method (CPM) - Programme Evaluation and Review Technique (PERT). **L:6 T:3**

CO4: compute optimum solution of non – linear programming

Formulating a Non-Linear Programming Problem – Constrained Optimization with equality Constraints- Graphical Solution – Kuhn- Tucker Conditions with Non negative constraints- Quadratic Programming – Wolfe's modified Simplex method. **L:6 T:3**

CO5: solve non-linear constrained optimization

Optimization using Gradient Descent – Constrained optimization - Lagrange Multipliers - Convex optimization - Non linear Constrained Optimization. **L:6 T:3**

TEXT BOOKS

1. KantiSwarup, Gupta P.K and Man Mohan, Operations Research: Introduction to management Science, Sultan Chand &Sons, 20th Revised Edition, 2022.
2. Hamdy A Taha, Operations Research - An Introduction, 10th Edition, Pearson Education, 2019.

REFERENCES

1. Sharma JK., Operations Research, Trinity, New Delhi, 6th Edition, 2017.
2. Sundaresan.V, Ganapathy Subramanian. K.S. and Ganesan.K, Resource Management Techniques, A.R. Publications, 11th Edition, 2017.
3. Gupta P K, Mohan Man, Problems in Operations Research, Sultan Chand & Sons, 2014
4. V K Kapoor, Operations Research , Concept problems & solutions, Sultan Chand & Sons, 2017

L : 30; T :15; TOTAL : 45 PERIODS

Course Code	PRINCIPLES OF DISCRETE MATHEMATICS	L	T	P	E	C
23SH06E		2	1	0	0	3

COURSE OUTCOMES:

Upon successfully completing the course, the students will be able to:

CO1: illustrate the validity of the arguments. (CDL 1)
CO2: analyze the concepts of Sets, Relations and Functions. (CDL 1)
CO3: perform the principles of counting and solve recurrence relations. (CDL 1)
CO4: interpret the basic concepts of graphs. (CDL 1)
CO5: compute minimum Spanning Trees and shortest route for the graph. (CDL 1)

CO1: illustrate the validity of the arguments.

Propositional Logic – Equivalences and Implications – Normal forms – Rules of inference – Proof methods and Strategies - Forward Proof, Proof by Contradiction, Proof by Contraposition, Proof of Necessity and Sufficiency. **L:6 T:3**

CO2: analyze the concepts of Sets, Relations and Functions

Basic Definitions - Set operations – Laws of set theory – Relations – Properties of relations - Equivalence Relation - Matrices of relations - Closure of relations – Functions – Bijective functions - Inverse and Compositions of functions. **L:6 T:3**

CO3: perform the principles of counting and solve recurrence relations.

Mathematical induction - Strong induction and well ordering -The basics of counting – The pigeonhole principle - Recurrence relations – Solving linear recurrence relations – Generating functions - Inclusion and exclusion principle. **L:6 T:3**

CO4:interpret the basic concepts of graphs

Graphs and their properties - Special types of graphs – Matrix representation of graphs and graph isomorphism- Euler and Hamiltonian graphs. **L:6 T:3**

CO5: compute minimum Spanning Trees and shortest route for the graph

Trees – Some properties of Trees – Pendant vertices in a Tree – Distance and centers in a Tree – Rooted and Binary Trees - Spanning Trees- minimum spanning tree–Prim's algorithm. **L:6 T:3**

TEXT BOOKS

1. Kenneth H.Rosen, Discrete Mathematics and its Applications (with Combinatory and Graph Theory), Special Indian Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 8th Edition, 2021.
2. Trembly J.P and Manohar.R. Discrete Mathematical Structures with Applications to Computer Science, first Edition, Tata McGraw-Hill Pub. Company Limited, New Delhi, 2020.
3. Narsingh Deo, Graph Theory with Applications to Engineering and Computer Science, 1st Edition, Dover Publications Inc., 2016.

REFERENCES

1. Ralph .P. Grimaldi, Discrete and Combinatorial Mathematics: An Applied Introduction, 5th Edition, Pearson Education Asia, Delhi, 2019.
2. Bondy, J.A., Murty.U.S.R., Graph Theory with applications, North Holland publication, 2008.
3. K.Balakrishnan, Schaum's Outline of Graph Theory, Tata Mc Graw-Hill Pub, 2020.
4. Richard J.J, Introduction to Graph Theory, 1st Edition, Parker Pub. Company, 2017.

L : 30; T :15; TOTAL : 45 PERIODS

Course Code	RANDOM PROCESSES AND QUEUEING THEORY	L	T	P	E	C
23SH07E		2	1	0	0	3

COURSE OUTCOMES:

Upon successfully completing the course, the students will be able to:

CO1: interpret the basic characteristic features of Random processes. (CDL 1)

CO2: encapsulate the time averages of uncertain events. (CDL 1)

CO3: evaluate spectral densities of functions. (CDL 1)

CO4: analyze the characteristics of Markovian queues. (CDL 1)

CO5**:**apply the concepts of queuing theory in networks.(CDL 1)

CO1: interpret the basic characteristic features of Random processes **L:6 T:3**

Classification - Stationary process - Markov process - Markov chains - Transition probabilities.

CO2 : encapsulate the time averages of uncertain events **L:6 T:3**

Counting Process - Ergodic process - Poisson Process - Renewal Processes - Gaussian process.

CO3 :evaluate spectral densities of functions **L:6 T:3**

Auto correlation - Cross correlation – Power spectral density–Cross spectral density-Properties–Wiener – Khintchine theorem (without proof).

CO4 : analyze the characteristics of Markovian queues

Markovian models – Birth and Death Queuing models- Steady state results: Single and multiple server queuing models- queues with finite waiting rooms- Finite source models- Little's Formula. **L:6 T:3**

CO5: apply the concepts of queuing theory in networks **L:6 T:3**

M/G/1 queue- Pollaczek- Khintchine formula, series queues- open and closed networks.

TEXT BOOKS

1. Oliver C. Ibe, "Fundamentals of Applied Probability and Random processes", Academic Press, 2nd Edition, 2014.
2. Hwei Hsu, "Schaum's Outline of Theory and Problems of Probability, Random Variables and Random Processes, Tata McGraw-Hill Education, 3rdEdition, 2017.
3. John F Shortle, James M Thompson, Donald Gross and Carl M Harris, "Fundamentals of Queueing Theory", Wiley and Sons Publication Limited, 5thEdition, 2018.

REFERENCES

1. Miller.S.L and Childers, S.L, Probability and Random Processes with applications to Signal Processing and Communications, Elsevier Inc., 2nd Edition, 2012.
2. Peyton. Z. Peebles Jr., Probability Random Variables and Random Signal Principles, 4th Edition, Tata McGraw-Hill Publishers, New Delhi, 2017.
3. Erwin Kreyszig, "Advanced Engineering Mathematics", 10thEdition, Wiley India, 2017.

L : 30; T :15; TOTAL : 45 PERIODS

Course Code	STATISTICAL TECHNIQUES AND NUMERICAL	L	T	P	E	C
23SH08E	METHODS	2	1	0	0	3

COURSE OUTCOMES:

Upon successfully completing the course, the students will be able to:

CO1: calculate the various measures of dispersion. (CDL 1)

CO2: apply the principles of hypothesis testing in small and large samples. (CDL 1)

CO3: analyze the variances in design of experiments. (CDL 1)

CO4: find solution of linear equations and to perform differentiation and integration numerically. (CDL 1)

CO5: compute numerical solution of differential equations. (CDL 1)

CO1: calculate the various measures of dispersion

Central tendencies - Mean, median, mode - Measures of Dispersion –Mean deviation, and Quartile deviation–Moments– Skewness –Kurtosis - Correlation and Regression. **L:6 T:3**

CO2: apply the principles of hypothesis testing in small and large samples

Sampling distributions - Statistical hypothesis - Large sample testsbased on Normal distribution for single mean and difference of means -Tests based on t, and F distributions - Chi-square -Contingency table for independent of attributes – Goodness of fit. **L:6 T:3**

CO3: analyze the variances in design of experiments

One way and two way classifications - Completely randomized design – Randomized block design – Latin square design – 2^2 factorial design. **L:6 T:3**

CO4: find solution of linear equations and to perform differentiation and integration numerically

Solution of algebraic and transcendental linear equations - Newton - Raphson Method- Solution of simultaneous equations – Gauss Elimination method – Gauss Seidel method – Interpolation – Lagrange's Method - Numerical Differentiation – Newton's forward difference and backward difference formula – Numerical integration - Single integration using Trapezoidal and Simpson's 1/3 rd and 3/8 th rules. **L:6 T:3**

CO5: compute numerical solution of differential equations

Taylor's Series Method – Euler's Method – Runge Kutta fourth order Method – Predictor - corrector Methods – Milne's Method - Solution of one dimensional heat equation by explicit and implicit methods(Crank Nichelson and Bender Schmidth methods) - Two dimensional Laplace and Poisson equations. **L:6 T:3**

TEXT BOOKS

1. Richard A. Johnson, "Miller and Freund's Probability and Statistics for Engineers", 9th Edition, Pearson Education Private Ltd., 2018.
2. Grewal, B.S., "Numerical Methods in Engineering & Science: With Programs in C, C++ & MATLAB", 11th Edition, Khanna Publishers, New Delhi, 2014.

REFERENCES

1. Dharmaraja Selvamuthu, Dipayan Das, Introduction to Statistical Methods, Design of Experiments and Statistical Quality Control, Springer Verleg Singapore Pvt. Ltd., 2018.
2. S.C. Gupta and V.K. Kapoor, "Fundamentals of Mathematical Statistics, 12th Edition, Sultan Chand & Sons, Delhi, 2014.
3. M.K.Jain.S.R.K.Iyengar,R.K.Jain "Numerical Methods for scientific and Engineering Computation", 6th Edition, New age International Publishers, 2019.
4. Chapra, S. C and Canale, R. P. "Numerical Methods for Engineers", 8th Edition, Tata McGraw - Hill, New Delhi, 2021.

L : 30; T :15; TOTAL : 45 PERIODS

Course Code	TRANSFORMS, MATHEMATICAL LOGIC AND SET	L	T	P	E	C
23SH09E	THEORY	2	1	0	0	3

COURSE OUTCOMES:

Upon successfully completing the course, the students will be able to:

Theory Components:

CO1: apply Laplace transform to solve ordinary differential equations. (CDL 1)
CO2: compute the Fourier transforms of various functions. (CDL 1)
CO3: solve difference equations using Z-Transform. (CDL 1)
CO4: illustrate the validity of the arguments. (CDL 1)
CO5**:** analyze the concepts of Sets, Relations and Functions. (CDL 1)

CO 1 : apply Laplace transform to solve ordinary differential equations

Definition of Laplace transform and its inverse – Transforms of elementary functions – Properties – Transforms of periodic functions – Initial and final value theorems – Convolution theorem.- solutions of linear ordinary differential equations with constant coefficients. **L:6 T:3**

CO2 : compute the Fourier transforms of various functions

Fourier Integral theorem (without proof)–Fourier transform pair–Fourier Sine and Cosine transforms–Properties–Transforms of simple functions–Convolution theorem –Parseval's theorem. **L:6 T:3**

CO3 : solve difference equations using Z-Transform

Z– transform –Elementary properties – Inverse Z–transform – Convolution theorem- Initial and final value theorem – Formation of difference equations –Solutions of difference equations using Z–transform. **L:6 T:3**

CO4: illustrate the validity of the arguments.

Propositional Logic – Equivalences and Implications – Normal forms – Rules of inference – Proof methods and Strategies - Forward Proof, Proof by Contradiction, Proof by Contraposition, Proof of Necessity and Sufficiency. **L:6 T:3**

CO5: analyze the concepts of Sets, Relations and Functions

Basic Definitions - Set operations – Laws of set theory – Relations – Properties of relations - Equivalence Relation - Matrices of relations - Closure of relations – Functions – Bijective functions - Inverse and Compositions of functions **L:6 T:3**

TEXT BOOKS

1. Grewal.B.S. "Higher Engineering Mathematics", 44th Edition, Khanna Publications, Delhi, 2021.
2. Kenneth H.Rosen, Discrete Mathematics and its Applications, Tata McGraw-Hill Publishing Company Limited, New Delhi, 8th Edition, 2021.
3. Erwin Kreyszig, "Advanced Engineering Mathematics", 10thEdition, Wiley India, 2017.

REFERENCES

1. Ramana B.V, "Higher Engineering Mathematics", Tata Mc-Graw Hill Education, New Delhi, 2017.
2. Trembly J.P and Manohar.R. Discrete Mathematical Structures with Applications to Computer Science, 1st Edition, Tata McGraw-Hill Pub. Company Limited, New Delhi, 2017.
3. J K Goyal, K.P.Gupta, Laplace and Fourier Transforms, Pragati Prakashan, 2016

L : 30; T :15; TOTAL : 45 PERIODS

Course Code	**FUNDAMENTALS OF LASER TECHNOLOGY**	**L**	**T**	**P**	**E**	**C**
23SH10E		**3**	**0**	**0**	**0**	**3**

COURSE OUTCOMES:

Upon successfully completing the course , the students will be able to:

CO1: explain the fundamentals of lasers (CDL1)

CO2: demonstrate the laser surface modification process (CDL1)

CO3: describe the laser machining processes (CDL1)

CO4: identify the laser measurement and testing process (CDL1)

CO5: organizethe advanced applications and safety measures of laser (CDL1)

CO1: explain the fundamentals of lasers

Characteristics of laser -laser principle- population inversion-line broadening mechanisms-Q switching - threshold condition for laser-three-level and four-level systems-conditions for continuous wave (CW) and pulsed laser action- pumping schemes-classification of lasers: Er:YAG - carbon dioxide lasers - argon laser - X-Ray lasers - fiber lasers - Raman lasers. **L:9**

CO2: demonstrate the laser surface modification process

Laser surface heat treatment: process parameters - advantages and disadvantages of laser surface treatment; laser surface melting - laser direct metal deposition: processing parameters - methods for applying the coating material- laser alloying and cladding - advantages and disadvantages -laser physical vapor deposition - laser shock peening: analysis - advantages and disadvantages **L:9**

CO3: describe the laser machining processes

Laser welding parameters: beam power, spot diameter and traverse speed; welding efficiency; mechanism of laser welding: conduction mode welding, keyhole welding; laser cutting – process characteristics-fusion cutting, sublimation cutting, photochemical ablation;laser drilling –single pulse drilling-percussion drilling, trepanning applications - laser marking - dot matrix marking, engraving, image micro machining -lasers for marking - application **L:9**

CO4: identify the laser measurement and testing process

Laser for measurement - distance -length-velocity-acceleration-current-voltage-atmospheric effect-laser application in spatial frequency filtering. **L:9**

Holography: basic principle - methods - Holographic interferometry and applications-holography for non – destructive testing – holographic components

CO5: organizethe advanced applications and safety measures of laser

Laser advanced application in defence-laser weapons- industry for material handling: ASRS and AGV- medicine -laser activated therapy - photodynamic therapy, laser angioplasty, lasers in surgery - photocoagulation, photodisruption and photoablation - laser scanning confocal microscopy - Laser safety - danger - safety limits for eye and skin - class four safety arrangements - electric hazards- chemical hazards - fume hazards - explosion hazards - safety guidelines **L:9**

TEXTBOOKS:

1. William M. Steen, “Laser Material Processing”, Springer Verlag, 2010
2. K.Thyagarajan, AjoyK.Ghatak, “Lasers, Theory and Applications”, Springer, 2nd Edition, 2011.
3. Chunlei Guo, Subhash Chandra SinghHandbook of Laser Technology and Applications Lasers Applications: Materials Processing and Spectroscopy, 2nd Edition, (Vol.3), 2021

REFERENCES:

1. Uday Shanker Dixit, Shrikrishna N. Joshi, J. Paulo Davim, "Application of Lasers in Manufacturing" Springer Singapore, 1st Edition, 2019
2. Stephan Wieneke and Christoph Gerhard, "Lasers in Medical Diagnosis and Therapy Basics, applications and future prospects" IOP Publishing Ltd, 2018
3. AK Katiyar, CK Pandey and Manisha Bajpai, "Fundamentals of Laser Systems and Applications", Wiley, 2017.

L : 45; TOTAL : 45 PERIODS

Course Code		L	T	P	E	C
23SH11E	**NANOMATERIALS FOR ENGINEERS**	**3**	**0**	**0**	**0**	**3**

COURSE OUTCOMES:

Upon successfully completing the course , the students will be able to:

CO1: explain the fundamentals of nanomaterials (CDL1)

CO2: interpret the different properties of nanomaterials (CDL1)

CO3: demonstrate the synthesis of nanomaterials (CDL1)

CO4: illustrate the characterization of nanomaterials (CDL1)

CO5: organize the applications of nanomaterials(CDL1)

CO1: explain the fundamentals of nanomaterials

Introduction to nanomaterials - size effect - specific surface area - surface to volume ratio - quantum confinement effects - morphology - density - melting point - wettability - classification based on the dimension - nanoparticles - nanowires - nanoclusters - nanotubes - quantum wells - metal based nanomaterials - nanocomposites - carbon nanotubes - nanosized metals - alloys - semiconductors - ceramics **L:9**

CO2: interpret the different properties of nanomaterials

Mechanical behavior- comparison of bulk and nano materials - elastic and plastic deformation - tensile strength - superplasticity -hardness - nano hardness -influence of porosity - grain size – thermodynamics of nanoparticles- heat capacity – phase transformation of nanoparticles- electrical and optical properties: electrical conductivity in nano tubes, nano rods and nanocomposites - photoconductivity of nanorods - electroluminiscesnce in nanoparticles- magnetic properties: magnetic hysteresis - superparamagnetism **L:9**

CO3: demonstrate the synthesis of nanomaterials

Bottom-up and top-down approach - inert gas condensation - plasma arc technique - ion sputtering - ball milling - molecular beam epitaxy - chemical vapour deposition - method - electrodeposition - ultrasonication - microemulsions method - solvothermal synthesis - microwave assisted synthesis. **L:9**

CO4: illustrate the characterization of nanomaterials

X-ray diffraction - energy dispersive spectrum - atomic force microscopy - high resolution transmission electron microscopy - Raman spectroscopy - x-ray photoelectron spectroscopy - electrochemcial characterization measurements - cyclic voltammetry - linear sweep voltametry - Brunauer-Emmett-Teller - surface area analysis - nanoindentation - determination of nano hardness. **L:9**

CO5: organize the applications of nanomaterials

Functional graphene - carbon nanotube - polymer composite applications in defence and

aerospace - nanomaterials for solar cells - nanoscale catalysts for energy and automobile industries - rechargeable batteries based on nanomaterials - nanomaterials for electrodes and wearable electronics - nano based coating and paints - nanosensors -gas sensors - bio sensors - nano electro mechanical systems **L:9**

TEXTBOOKS:

1. Charles P Poole, Frank J Ownes, Introduction to Nanoscience and Nanotechnology, An Indian Adaption, Wiley, 2020
2. Hornyak, G.Louis, Tibbals, H.F., Dutta, Joydeep, Fundamentals of Nanotechnology, CRC Press, 1st Edition, 2018
3. Dieter Vollath, Nanomaterials an introduction to synthesis, properties and applications, Wiley, 2nd Edition, 2013

REFERENCES:

1. Narendra Kumar, Sunita Kumbhat, Essentials in Nanoscience and Nanotechnology, Wiley, 1st Edition, 2016
2. G. Cao,Ying Wang, Nanostructures and nanomaterials: Synthesis, properties and applications, Imperial College Press, 2nd Edition, 2011
3. B.S. Murty , P. Shankar , Baldev Raj , B B Rath , James Murday, Textbook of Nanoscience and Nanotechnology, Springer, 1st Edition, 2013

L : 45; TOTAL : 45 PERIODS

Course Code	**PHOTONICS**	**L**	**T**	**P**	**E**	**C**
23SH12E		**3**	**0**	**0**	**0**	**3**

COURSE OUTCOMES:

Upon successfully completing the course , the students will be able to:

CO1: explain the basics of photonics (CDL1)

CO2: demonstrate the properties of photonic crystal (CDL1)

CO3: outline the basics of bio photonics (CDL1)

CO4: interpret the quantum confinement in photonic materials(CDL1)

CO5: organize the applications of photonic materials (CDL1)

CO1:explain the basics of photonics

Wave phenomena – interference, diffraction-photon properties - energy, flux, statistics-Interaction of photons with atoms-optical amplification-three and four level system -EDFA-semiconductor light sources-detectors-light manipulation - birefringence - Faraday's rotation - interaction of light with RF and acoustic waves - Raman-Nath diffraction experiment . **L:9**

CO2: demonstrate the properties of photonic crystal

Electromagnetic theory of light-electromagnetic properties of material- polarization of light; Reflection and refraction- Fresnel equations; absorption, dispersion, and scattering of electromagnetic waves -Bragg grating; 1D photonic crystals -photonic band structure-real and reciprocal lattices; 2D and 3D photonic crystals-emerging applications of photonic crystals - 1D Bragg grating - periodic dielectric wave guide - 2D photonic crystal slab and fibre. **L:9**

CO3:outline the basics of bio photonics

Fundamentals of light and matter-basics of light-matter interactions in molecules, cells and tissues -lasers for biophotonics -bioimaging: principles and applications-transmission microscopy, Kohler illumination-optical biosensors-light activated therapy: photo thermal **L:9**

and photo dynamic therapy- tissue engineering with light- optical tweezers, scissors and traps - bio nanophotonics applications - bio chip - DNA micro-arrays - gene chip - lab on chip.

CO4:interpret the quantum confinement in photonic materials

Quantum confined materials: quantum wells, quantum wires, quantum dots, quantum rings, manifestations of quantum confinement, optical properties, quantum confined stark effect, dielectric confinement effect. **L:9**

Nanoplasmonics: optical response of metals, plasmons, optical properties of metal nanoparticles, size dependent absorption and scattering, coupled nanoparticles - metal-dielectric core-shell nanoparticles - local electromagnetic fields in metal nanoparticles.

CO5: organize the applications of photonic materials

Excitation energy transfer – device operation: nanophotonic AND gate - nanophotonic OR gate – interconnection with photonic devices - metamaterials concept; super lens, hyperbolic metamaterials and application in high-resolution imaging: hyper lens - tunable photonic metamaterials based devices - electro-optical metamaterials - phase-change metamaterials - metamaterials in solar energy harvesting - perfect absorbers and thermal emitter **L:9**

TEXTBOOKS:

1. Bahaa E. A. Saleh, Malvin Carl Teich, Fundamentals of Photonics, 3rdEdition, Wiley,2019.
2. Brian Culshaw, Introducing Photonics, Cambridge University Press, 2020.
3. Gerd Keiser, Biophotonics: Concepts to Applications, second edition, Springer Nature Singapore Pvt. Ltd 2022.

REFERENCES:

1. Joseph W. Haus, Fundamentals and Applications of Nanophotonics, Woodhead Publishing, 2016.
2. W.Cai and V. Shalaev, Optical Metamaterials: Fundamentals and Applications, 2nd Edition, Springer, 2024.
3. P PYupapin, K Srinuanjan, S Kamoldilok, Devices, Circuits and Systems: Nanophotonics, Pan Stanford Publishing, 2013.
4. Paulo Ribeiro, Maria Raposo, "Optics, Photonics and Laser Technology", Springer International publishing, 1st Edition, 2018

L : 45; TOTAL : 45 PERIODS

Course Code		L	T	P	E	C
23SH13E	**BIOLOGY FOR COMPUTING**	**3**	**0**	**0**	**0**	**3**

COURSE OUTCOMES:

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

CO1: describe the structure, interaction and applications of biomolecules
CO2: interpret the structure and functions of the gene and protein using the bioinformatics data
CO3: simulate the behavior of simple biological models using computational softwares
CO4: identify and design molecules for new drug development by computational methods

CO1: describe the structure, interaction and applications of biomolecules **L:9**

Biomolecules-I :

Introduction – monomeric units and polymeric structures of carbohydrates, proteins, nucleic acids and lipids. Enzymes: enzymatic action via Lock and key – Enzyme therapy - immune response monitoring – molecular modification – encapsulation. Agarose gel electrophoresis:

SDS, PAGE and 2D – Molecular interactions: covalent and non-covalent interactions, antigen – antibody interactions. Methods to measure the interactions: UV-visible and single crystal X-ray diffraction.

Biomolecules -II **L:9**

Chromosome structure and function – chromosome abnormalities – chromosome dynamics – nuclear architecture. DNA transcription, replication and segregation. DNA finger printing. Pedigree analysis. Identifying human disease genes (functional cloning versus positional cloning; mutation screening). Human genome project: introduction – steps – salient features. Hap map project – salient features.

CO2: interpret the structure and functions of the gene and protein using the bioinformatics data **L:9**

Bioinformatics: introduction – biological databases – types. DNA databases – EMBL, gene bank, DDBJ. Protein databases: Swiss Prot/TrEMBL, PIR. Sequence motif databases - Pfam, PROSITE, Protein structure databases, protein data Bank – SCOP, CATH, and KEGG. Sequence analysis – methods of sequencing: sangar method, maxama - gilbert method and edman degradation method, NGS methods of sequencing.Basic local alignment search tool (BLAST) – types – determining the identity of an organism from its r DNA gene nucleotide sequence. Softwares for handling the databases – ChemDiff.

CO3: simulate the behavior of simple biological models using computational softwares **L:9**

Quantum mechanics: influence of physics on theoretical chemistry. Semi empirical methods – slater determinants – Hartree – Fock equation. Semi empirical models - Ab-initio calculations: Thermodynamic functions – koopmans's theorem – isodesmic reactions, Density functional theory for larger molecules. Introduction to Gaussian and ADF : Geometry optimization, frequency calculation, location of transition state, intrinsic reaction co-ordinates, molecular orbitals and population analysis, natural bond orbital analysis, calculation of equilibrium constants and rate constants. Introduction to GROMACS: GROMACS input files, simulations of liquid water, water methanol mixtures, S-peptide and free energy of salvation. Introduction to SCILAB- Scilab programming: Curve fitting, integral transforms and introduction to molecular dynamics. Execution of programs for liquid argon.

CO4: identify and design molecules for new drug development by computational methods **L:9**

Drug design: General approach to discovery of new drugs – lead modification – calculation of the various drug likeness rules like Lipinski's rule, MDDR - like rule, Veber rule, Ghose filter, BBB rule, CMC-50 like rule and Quantitative estimate of drug-likeness (QED) using DruLiTo and Swiss ADMEsoftware. Pharmacokinetic properties of drug using Osiris and Molinspiration software. Structure-based drug designing approaches - target identification and validation - physiochemical principles of drug action – drug stereo chemistry – drug action - 3D database – computer aided drug design. Identification of the suitable target using Pharmmapper - Molecular docking programs using Autovina softwares and visualization tools - Preparation of protein and ligand using ADT and pymol-generation of paper publication-quality images and data analysis-protein-protein docking-Protein DNA docking

TEXT BOOKS

1. Shawn T. O'Neil, A Primer for Computational Biology, Oregon State Campus, Corvallis, USA, 2019.
2. Frank Jensen, Introduction to Computational Chemistry, 3rd Edition, Wiley publishing LLC. USA, 2016
3. Philly Charles, Genes, Genomes, Genetics and Chromosomes, Nottinghamshire, England, 2020.

REFERENCES

1. Ariel Fernández Stigliano, Biomolecular Interfaces: Interactions, Functions and Drug Design, 1st Edition, Springer International Publishing AG, London, 2016.
2. S.C. Rastogi, P.Rastogi, N.Mendiratta, Bioinformatics: Methods and Applications - Genomics, Proteomics and Drug Discovery, 5th Edition, PHI Learning Pvt. Ltd., Delhi, 2022.
3. Robert A. Copeland, Enzymes: A Practical Introduction to Structure, Mechanism, and Data Analysis, 3rd Edition, Wiley-Blackwell, New York, 2023.

L: 45; TOTAL: 45 PERIODS

Course Code		L	T	P	E	C
23SH14E	**BIOLOGICAL SYSTEMS FOR ENGINEERS**	3	0	0	0	3

COURSE OUTCOMES:

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

CO1: understanding of bio design principles to create novel devices and structures and cell biology

CO2: explain the structure and stability of biomolecules

CO3: describe the principle, components and applications of various instruments for medical diagnosis

CO4: interpret the major bio-energetic pathways

CO5: explain the properties characterization and application of various biomaterials

CO1: understand the basic principles of biology to create novel devices **L:9**

Cell - prokaryotic and eukaryotic cells - plant cell and animal cell - structural and function of Mitochondria - Chloroplast - Lysosomes - Golgi bodies - Nucleus. Cell cycle: mitosis and meiosis. Bioinspired devices: GPS, aircrafts, swim suits, bullet train, super hydrophobic and self-cleaning surfaces.

CO2: explain the structure and stability of biomolecules **L:9**

Introduction - monomeric units and polymeric structures of carbohydrates, proteins, nucleic acids and lipids. Molecular interactions: covalent and non-covalent interactions – methods of quantification and determination: UV – visible, CD, and SPR.

Enzymes - classification - specific activity - enzyme activity - chemical nature of enzymes. Protein and non-protein nature of enzymes. Metalloenzymes and metal activated enzymes. Industrial applications of enzymes: biosensors and bio bleaching.

CO3: describe the principle and applications of various instruments for medical diagnosis **L:9**

Basic concepts of instrumentation: static and dynamic characteristics, design criteria, instrumentation, amplifiers. Biopotential electrodes: fundamentals - body surface electrodes - microelectrodes - Principle, components and applications of microscope: light and electron microscope. Electrocardiograph, glucometer, CT, magnetic resonance imaging, ultrasonic imaging. Artificial Intelligence for disease diagnosis.

CO4: interpret the major bio-energetic pathways **L:9**

Thermodynamics in biological systems - exothermic and endothermic versus endergonic and exergonic reactions - concept of K_{eq} and its relation to standard free energy - spontaneity - ATP as an energy currency. Glucose synthesis from CO_2 + H_2O (photosynthesis) – decomposition of glucose (Glycolysis and Krebs cycle). Energy

yielding and energy consuming reactions. Concept of energy charge. Regulation of glycogenesis - measurement of blood glucose level.

CO5: explain the properties, characterization, and applications of various biomaterials. **L:9**

Biomaterials: introduction - types: alloys, polymers. Composites - properties: biocompatibility, elasticity, immune compatibility, resorbability, cytotoxicity, hemocompatibility and biodegradability. Physicochemical characterization: XRD and SEM. Applications: tissue engineering, heart valves, dental and orthopaedic implants.

TEXT BOOKS

1. Y.Nelson, L.David, Lehninger, "Principles of Biochemistry", International Edition. New York, 7th Edition, 2017.
2. Nagata, Kazuhiro, Real-Time Analysis of Biological Interactions, Springer, Japan, 3rd Edition, 2015.
3. I. Bertini, H.B Gray, Bioinorganic Chemistry, University Science Book, California, 4thEdition, 2014.

REFERENCES:

1. P.N.Bartlett, Bioelectrochemistry: Fundamentals, Experimental Techniques and Applications, 2nd Edition, John Wiley & Sons, New Delhi, 2014.
2. Ratner and Hoffmann, Biomaterial Science: An Introduction to Materials in Medicine, 2nd Edition, Elsevier Academic Press, London, 2015.
3. Lesile Cromwell, "Bio-medical instrumentation and measurement", Prentice Hall of India, New Delhi, 2nd Edition, Reprint, 2017.

L: 45; TOTAL: 45 PERIODS

Course Code		L	T	P	E	C
23SH15E	POLYMER SCIENCE AND TECHNOLOGY	3	0	0	0	3

COURSE OUTCOMES:

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

CO1: acquire knowledge on structure - property relationship of polymers

CO2: identify the suitable polymerization techniques for the large scale synthesis of polymers

CO3: explain the basic principles of various polymer processing techniques and their applications

CO4: interpret the chemical, thermal, electrical, and mechanical properties of the polymers

CO5: familiar with plastics waste disposal, value addition, associated environmental issues and legislation

CO1: acquire knowledge on structure - property relationship of polymers **L: 9**

Basic concepts of polymerization - polydispersity - conformation and configuration of macromolecules - stereo isomerism and tacticity in polymers - geometrical isomerism. Structure - property relationship -molecular force and chemical bonding in polymers - effect of polymerization on PDI. General rules for polymer solubility - crystallinity and orientation in polymers. Polymer chain flexibility: concept - factors deciding polymer flexibility - amorphous and crystalline polymers - crystallinity in polymers - factors affecting crystallinity - properties affected by crystallinity of polymers. Glass transition temperature and crystalline melting points. Factors affecting glass transition temperature.

CO2: identify the suitable polymerization techniques for the large scale synthesis of polymers **L:9**

Basic aspects of polymer synthesis - bulk, solution and suspension polymerization (styrene and MMA) - emulsion polymerization (vinyl acetate, styrene) - preparation of phenolic and epoxy resins. Modern techniques in polymerization: metathesis polymerization - controlled polymerization methods, viz., nitroxide mediated polymerization (NMD), atom transfer radical polymerization (ATRP), group transfer polymerization (GTP), and reversible addition fragmentation termination (RAFT).

CO3: explain the basic principles of various polymer processing techniques and their applications **L:9**

Plastics technology: raw materials - additives for compounding (fillers, plasticizers and softeners, lubricants, promoters, anti-aging additives, flame retarders, colorants, blowing agents, UV stabilizers,) - requirements and functions of additives. Pre-compounding operations: mixing, drum blenders, ribbon blenders, mixing rolls, internal mixers, mixing extruders, blenders for making organosol and plastisol, granulators, pelletizers.

Advanced fabrication techniques: RTM, RIM, filament winding, BMC/SMC. Post-forming and finishing, machining, welding and design of polymers products. Selections of polymers, additives, mold design. Analysis of defects in moulded products. Processing of reinforced thermoplastics and thermosets: manual processing methods and semi-automatic processing methods. Rubber processing: internal mixer and open mill.

CO4: interpret the chemical, thermal, electrical, and mechanical properties of polymers **L:9**

Physical testing: density, mechanical behaviour, MFI, and water/solvent adsorption. Chemical testing: ignition - pyrolysis - solvent extraction - elemental analysis. Thermal analysis: vicat softening point - dynamic mechanical thermal analysis. Morphological analysis: atomic force microscopy and chemical force microscopy. Spectroscopic analysis: IR peaks assigned for rubber. Study of hydrogenation, halogention, evidence for cyclization and formation of ionomers. Analysis of carbon filled rubber - Case studies.

CO5: familiar with plastics waste disposal, value addition, associated environmental issues and legislation **L-9**

Polymer waste: sources, collection, segregation, and identification by simple techniques. Life cycle assessment, risk factor analysis. Plastics waste management techniques: chemical recycling, thermal conversion technologies, microbial, microwave, and ultrasonic. Use of plastics waste for value addition. Plastics waste management rule - environmental issues.

TEXT BOOKS

1. Premamoy Ghosh, Polymer Science and Technology: Plastics, Rubber, Blends and Composites, 3rd Edition, McGraw Hill Education, 2017.
2. Richard A Petherick, Polymer Science and Technology for Engineers and Scientists, Whittles Publishing, 2010.
3. Michael L. Berins, SPI Plastics Engineering Handbook of the Society of the Plastics Industry, Inc. 1st Edition, Springer New York, 2012
4. Vishu Shah, Handbook of Plastics Testing Technology,2nd Revised edition, Wiley–Blackwell, 1998**.**

REFERENCES

1. Gowarikar V R, Polymer science, 5th Edition, New Age International Private Limited, 2023
2. Fred W. Billmeyer, Textbook of Polymer Science, 3rd Edition, John Wiley & Sons, 2007
3. Nayak S.K, Text Book on Fundamentals of Plastics Testing, Springer (I) Private Limited, 2020
4. J S Anand, Recycling & Plastics Waste Management, Central Institute of Plastics Engineering and Technology, 1997.
5. Korschwitz J, Polymer Characterization and Analysis, John Wiley and Sons, 1990.

L: 45; TOTAL: 45 PERIODS

Course Code		L	T	P	E	C
23SH16E	SENSORS FOR ENGINEERING APPLICATIONS	3	0	0	0	3

COURSE OUTCOMES:

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

CO1: Gain knowledge on basic concepts of sensors and Transducer.

CO2: know about the thermal and motion sensors for various applications.

CO3: enumerate the principles and applications of optical and magnetic sensors and transducers used in various field.

CO4: explain the construction, working principle and applications of electrochemical and electric sensors.

CO5: Design the sensors for environmental monitoring

CO1: Gain knowledge on basic concepts of sensors and Transducer. **L: 9**

Introduction – Historical development of sensors – Human body as a sensor system – sensors and transducers. Principle and classification of sensor. Sensor characteristics – sensor properties – various transducers – piezoelectric effect – pyroelectric effect – seebeck effect and peltier effect. Advantages and limitations of Sensors.

CO2: know about the thermal and motion sensors for various applications. **L:9**

Thermal sensors: introduction – types - primary sensor: gas thermometer and He low temperature thermometer. Secondary sensor: Resistance thermometer and NQR thermometer. Temperature sensing technologies: IC sensor, resistive temperature detectors, thermocouples and thermistor.

Motion sensors: Introduction and principle. Types: Infra red and microwave. Specialized motion sensor: proximity and ranging sensor. Motion Sensors in everyday life: The role of motion sensors in home security.

CO3: enumerate the principles and applications of optical and magnetic sensors and transducers used in various field **L:9**

Magnetic sensors: Introduction – principle and applications: magnetic field sensors and magneto-resistive Sensors, hall effect sensors.

Optical sensors: light intensity – wavelength and color – light dependent resistors, photodiode, photo transistor, CCD, CMOS sensors. Pulse oximeter, portable pulse oximeter, wearable pulse oximeter; wearable capnometer for monitoring of expired.

CO4: explain the construction, working principle and applications of electrochemical and electric sensors **L-9**

Electrochemical sensors: Introduction - fundamental concepts – chemiresistors. Conductometric sensor: amperometric sensor - potentiometric sensors - impendence sensors.

Electric sensors: Introduction- conventional volt and ammeters, high current sensors, (current transformers), high voltage sensors, High power sensors. Real time applications: Glucose Monitoring

Devices, GlucoWatch G2 Biographer, GlucoTrackTM; Pulse oximeter, Portable Pulse Oximeter, wearable pulse oximeter.

CO5: Design the sensors for environmental monitoring **L-9**

Environmental Sensor: Introduction - environmental quantities**:** time, moisture acidity/alkalinity, wind-chill, radioactive count rate. Surveying and security. Sensors for environmental monitoring. Smoke and fire detector. Pressure sensor in emission testing, pollution devices, and wind management systems.

TEXT BOOKS

1. Jacob Fraden, Handbook of Modern Sensors: Physics, Design and Applications, 5th edition, Springer Nature, New Delhi, 2016
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3. John Veteline, Aravind Raghu, Introduction to sensors, CRC press, New Delhi, 2011.
4. S Nihtianov, A. Luque Smart Sensors and MEMS, 2nd Edition, Woodhead Publishing Limited, New Delhi, 2018.
5. Edward Sazonov and Michael R. Neuman, Wearable Sensors - Fundamentals, Implementation and Applications, Elsevier publishing company, Amsterdam, Netherland,2014.

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1. Shantanu Bhattacharya,A K Agarwal, NripenChanda, Ashok Pandey and Ashis Kumar Sen Environmental, Chemical and Medical Sensors, Springer Verlag, Singapore,2018 .
2. Krzysztof Iniewski, Optical, Acoustic, Magnetic, and Mechanical Sensor Technologies, 1st Edition, CRC Press, New Delhi, 2017.

L: 45; TOTAL: 45 PERIODS