R
2022

(Regulation-2022)
I Semester to VIII Semester

Curriculum and Syllabus

for B.E - Electrical and Electronics Engineering

PSN College of Engineering and Technology
An Autonomous Institution, Affiliated to Anna University
Approved by AICTE, Accredited by NAAC with A+ Grade

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

Institute Vision and Mission

INSTITUTE VISION
• To emerge as a pioneer institute inculcating engineering education, skills, research, values and ethics.
INSTITUTE MISSION
• To achieve greater heights of excellence in technical knowledge and skill development through innovative teaching and learning practices. • To develop the state of art infrastructure to meet the demands of technological revolution. • To improve and foster research in all dimensions for betterment of society. • To develop individual competencies to enhance innovation, employability and entrepreneurship among students. • To instill higher standards of discipline among students, inculcating ethical and moral values for societal harmony and peace.

Department Vision and Mission

DEPARTMENT VISION
• To emerge as pre-eminence program for quality Electrical and Electronics Engineering Graduates.
DEPARTMENT MISSION
• To enable quality infrastructure for advanced knowledge and skills towards learning under congenial environment for global placement, higher studies, research and entrepreneurship. • To stimulate the process of critical thinking and problem solving with special focus on research capabilities. • To enhance professional ethics, values and standards to meet the demands of society

Program Educational Objectives (PEOs):

The graduates of Electrical and Electronics Engineering will be able to,

- Apply their knowledge and skills to provide solutions to electrical and electronics engineering problems in industry and governmental organizations or to enhance student learning in educational institutions.
- Work as a team with a sense of ethics and professionalism and communicate effectively to manage cross-cultural and multidisciplinary teams.
- Update their knowledge continuously through lifelong learning that contributes to personal, organizational, and societal growth.

PROGRAM OUTCOMES			
PO'S No.	**KNOWLEDGE**	**STATEMENT**	**APPLIANCE**
1	Engineering Knowledge	Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of Complex engineering problems.	Theory/ Practical / Project work
2	Problem Analysis	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	Theory / Practical / Projects
3	Design / Development of Solutions	Design solutions for complex engineering problems and design system components or processes that meet the needs with appropriate consideration for the public health and safety, and the cultural, Societal and environmental considerations.	Theory / Practical / Projects
4	Conduct Investigations of Complex	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of	Theory / Practical

	Problems	data, and synthesis of the information to provide valid conclusions.	
5	Modern Tool usage	Create, select, and apply appropriate techniques, resources and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.	Theory / Practical / Project work
6	The Engineer and Society	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	Theory / Industrial visit / In plant training
7	Environment and Sustainability	Understand the impact of the professional engineering solutions in societal and environmental contexts and demonstrate the knowledge of and need for sustainable development.	Theory / Industrial Visit/ In plant Training
8	Ethics	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	Theory / Industrial visit / In plant training
9	Individual and Team Work	Function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings.	Projects
10	Communication	Communicate effectively on complex engineering activities with the engineering community and with society at large such as being able to comprehend and write effective reports and design documentation, make effective presentations and give and receive clear instructions.	Projects/ Seminar/ Mini Project

11	Project Management and Finance	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	Projects
12	Life-long Learning	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	Projects / Higher Studies

Program Specific Outcomes (PSOs)

- To apply fundamental knowledge to identify, formulate and investigate various real-time problems of power systems and simulations.
- To apply recent techniques along with modern software tools for designing, simulating and analyzing electrical and renewable energy systems.

CURRICULUM - B.E. / EEE - I TO VIII SEMESTER

(Applicable to students those who are admitted from AY 2022-23)

S.No	Course code	Course Name	Classification		L	T	P	C
1	IC610001	Professional English - I	IC	Theory	2	0	0	2
2	IC610002	Matrices and Calculus	IC	Theory	2	1	0	3
3	IC610003	Engineering Physics	IC	Theory	3	0	0	3
4	IC610004	Engineering Chemistry	IC	Theory	3	0	0	3
5	CS610005	Problem Solving and 'C' Programming	IC	Theory	3	0	0	3
6	ME610006	Engineering Graphics with CAD	IC	Theory with Practical Component	2	0	2	3
7	IP610101	Physics and Chemistry Laboratory	IC	Practical	0	0	3	1.5
8	IP610102	Programming in 'C' Laboratory	IC	Practical	0	0	3	1.5
9		NCC/NSS/NSO *	IM	Institute Mandatory	1	0	0	0
10	IC610007	Tamil Marabu/Heritage of Tamil	IC	Theory	1	0	0	1
				Total	17	1	8	21

Semester - 02

11	IC620008	Professional English - II	IC	Theory with Practical Component	2	0	2	3
12	IC620009	Transforms & Partial Differential Equations	IC	Theory	2	1	0	3
13	IC620011	Semiconductor Physics	IC	Theory	3	0	0	3
14	CS620013	Fundamentals of Artificial Intelligence	IC	Theory	3	0	0	3

15	CS620014	Python Programming	IC	Theory	3	0	0	3
16	ME620015	Basic Engineering	IC	Theory	3	0	0	3
17	IP620103	Python Laboratory	IC	Practical	0	0	3	1.5
18	IP620104	Engineering Practice Laboratory	IC	Practical	0	0	3	1.5
19	IM620401	Environmental Studies	IM	Institute Mandatory	2	0	0	0
20	IC620016	Tamils and Technology	IC	Theory	1	0	0	1
				Total	25	1	8	22

Semester - 03

21	IC630017	Numerical Methods and Statistics	IC	Theory	3	0	0	3
22	EE630201	Analog Electronic Circuits	PC	Theory	3	0	0	3
23	EE630202	Measurements and Instrumentation	PC	Theory	3	0	0	3
24	EE630203	Electromagnetic Fields	PC	Theory with project	3	0	0	3
25	EE630204	Electric Circuits and Networks	PC	Theory with Practical Component	2	0	2	3
26		Professional Elective - I	PE	Theory	3	0	0	3
27	EE630301	Analog Electronic Circuits Laboratory	PC	Practical	0	0	3	1.5
28	EE630302	Measurements and Instrumentation Laboratory	PC	Practical	0	0	3	1.5
29	EE630501	Integrated Aptitude Skills - I (Lower)	EEC	Skill Based Course	0	0	1	0.5
30	IM630402	Universal Human Values	IM	Theory	2	0	0	0
				Total	19	0	9	21.5

Semester - 04

31	IC640018	Boundary Value Problems and Probability Distributions	IC	Theory	3	0	0	3
32	EE640205	Electrical Control Systems	PC	Theory with Practical Component	2	0	2	3
33	EE640206	DC Machines and Transformers	PC	Theory with project	3	0	0	3
34	EE640207	Linear Integrated and Digital logic Circuits	PC	Theory	3	0	0	3

35		Professional Elective - II	PE	Theory	3	0	0	3
36		Institute Elective - I	IE	Theory	3	0	0	3
37	EE640303	DC Machines and Transformers Laboratory	PC	Practical	0	0	3	1.5
38	EE640304	Linear and Digital Circuits Laboratory	PC	Practical	0	0	3	1.5
39	EE640502	Integrated Aptitude Skills - II (Lower)	EEC	Skill Based Course	0	0	1	0.5
40		Inplant Training (2 Weeks)	IM					
				Total	17	0	9	21.5

Semester - 05

41	EE650208	Power System Analysis	PC	Theory with Practical Component	2	0	2	3
42	EE650209	Power Electronics	PC	Theory with project	3	0	0	3
43	EE650210	Induction and Synchronous Machines	PC	Theory	3	0	0	3
44		Institute Elective - II	IE	Theory	3	0	0	3
45		Professional Elective - III	PE	Theory	3	0	0	3
46		Professional Elective - IV	PE	Theory	3	0	0	3
47	EE650305	Power Electronics Laboratory	PC	Practical	0	0	3	1.5
48	EE650306	Induction and Synchronous Machines Laboratory	PC	Practical	0	0	3	1.5
49	EE650503	Integrated Aptitude Skills - I (Higher)	EEC	Skill Based Course	0	0	2	1
50	EE650801	Energy Audit and Environment Management	PM	Theory	2	0	0	0
				Total	19	0	10	22

Semester - 06

51	EE660211	Digital Signal Processing in Electrical Engineering	PC	Theory with Practical Component	2	0	2	3
52	EE660212	Solid State Drives	PC	Theory with project	3	0	0	3
53		Microprocessor and Interfacing	PC	Theory	3	0	0	3
54		Institute Elective - III	IE	Theory	3	0	0	3
55		Professional Elective - V	PE	Theory	3	0	0	3

56		Professional Elective - VI	PE	Theory	3	0	0	3
57	EE660307	Microprocessor and Interfacing Laboratory	PC	Practical	0	0	3	1.5
58	EE660308	Power System Simulation Laboratory	PC	Practical	0	0	3	1.5
59	EE660504	Training on Electrical Computer Aided Design (ECAD)	EEC	Skill Based Course	0	0	2	1
60	IM660403	Professional Ethics	IM	Theory	2	0	0	0
61		Internship	IM					
				Total	19	0	10	22

Semester - 07

62	EE670213	Protection and Switchgear	PC	Theory	3	0	0	3
63	EE670214	Electric Vehicles	PC	Theory with project	3	0	0	3
64	EE670215	Power System Operation and Control	PC	Theory with Practical Component	2	0	2	3
65		Institute Elective - IV	IE	Theory	3	0	0	3
66		Professional Elective - VII	PE	Theory	3	0	0	3
67		Professional Elective - VIII	PE	Theory	3	0	0	3
68	EE670309	Electrical Estimation, Costing and Power Wiring Laboratory	PC	Practical	0	0	3	1.5
69	EE670310	Green Energy Laboratory	PC	Practical	0	0	3	1.5
70	MG670019	Innovation Entrepreneurship and Startups	IC	Theory	3	0	0	3
71	EE670505	Advanced Career Development	EEC	Skill Based Course	0	0	2	1
				Total	20	0	10	25

Semester - 08

72	EE680506	Project Work	EEC	Practical	0	0	20	10
				Total	0	0	20	10

TOTAL CREDITS: 165

PROGRAMME ELECTIVES

S. No	Vertical -1 - POWER ENGINEERING	Vertical - 2 - CONVERTERS AND DRIVES	Vertical - 3 - EMBEDDED SYSTEMS	Vertical - 4 - CONTROL AND INTRUMENTATION	Vertical - 5 - GREEN TRANSPORTATION	Vertical - 6 – ELECTRICAL AND COMPUTATIONAL SCIENCES	Vertical - 7 - DIVERSIFIED COURSES
1	Conventional and Alternate Energy Sources	Power Electronics for Renewable Energy Systems	ARM Processors and Controllers	Sensors and Actuators	Electric Vehicle Design	Object Oriented Programming Using Java	Hybrid Energy Technology
2	Generation and Utilization of Electrical Energy	Control of Power Electronics Circuits	Embedded Computing System Design	Industrial Instrumentation	Vehicle Dynamics and Control	Operating Systems and Architecture	Energy Efficient Buildings
3	Transmission and Distribution	Design of Switched Mode Power Supply	Real Time Operating Systems	Medical Electronics	Modeling, Simulation and Control of Electric Vehicles	Data Structures Using C++	Bluetooth Technology
4	Flexible AC Transmission Systems	Multilevel Power Converters	Design of Embedded Systems	Process Control	Design of Motor and Power Converters for Electric Vehicles	Data Analysis Using Python for Electrical Engineers	Deep Learning
5	High Voltage Engineering	Digital System Design (NPTEL)	Software for Embedded Systems	Logic and Distributed Control System	Design of Electric Vehicle Charging System	Data Management for Smart Grid	Edge Computing

6	Power System Transients	Advanced Power Electronics	Embedded Linux	Industrial Data Networks	Testing of Electric Vehicles	Communication and Data Security in Electrical Engineering	Fuzzy Systems and Applications
7	Power Quality	Design of Electrical Machines	Embedded Control Systems Design	Robotics and Automation	Grid Integration of Electric Vehicles	Communication Protocols, Security and Protection for Smart Grid	Municipal Solid Waste Management (NPTEL)
8	Power System Planning	Analysis of Electrical Machines	Embedded Control for Electrical Drives	Virtual Instrumentation	Fundamentals of Electric and Hybrid Vehicles	PLC Programming	Augmented Reality
9	Smart Grid: Basics to Advanced Technologies (NPTEL)	Analysis of Power Converters	Embedded System for Automotive Applications	Computer Control of Processes	Energy Storage and Management for Electric Vehicles	Machine Learning	MEMS Technology
10	Restructured Power Systems	Modern Rectifiers and Resonant Converters	Embedded Product Development	Instrumentation System Design	Intelligent and Autonomous Vehicles	Optimization Studies in Electrical Systems	Nano Sensors and Its Applications

PROGRAM ELECTIVE COURSES: VERTICLES

VERTICLE 1 – POWER ENGINEERING

S. No	Course Code	Course Title	L	T	P	No. of Contact Hours	C
1	EE606101	Conventional and Alternate Energy Sources	3	0	0	3	3
2	EE606102	Generation and Utilization of Electrical Energy	3	0	0	3	3
3	EE606103	Transmission and Distribution	3	0	0	3	3
4	EE606104	Flexible AC Transmission Systems	3	0	0	3	3
5	EE606105	High Voltage Engineering	3	0	0	3	3
6	EE606106	Power System Transients	3	0	0	3	3
7	EE606107	Power Quality	3	0	0	3	3
8	EE606108	Power System Planning	3	0	0	3	3
9	EE606109	Smart Grid: Basics to Advanced Technologies (NPTEL)	3	0	0	3	3
10	EE606110	Restructured Power Systems	3	0	0	3	3

VERTICLE 2 – CONVERTERS AND DRIVES

S. No	Course Code	Course Title	L	T	P	No. of Contact Hours	C
1	EE606201	Power Electronics for Renewable Energy Systems	3	0	0	3	3
2	EE606202	Control of Power Electronics Circuits	3	0	0	3	3
3	EE606203	Design of Switched Mode Power Supply	3	0	0	3	3
4	EE606204	Multilevel Power Converters	3	0	0	3	3
5	EE606205	Digital System Design (NPTEL)	3	0	0	3	3
6	EE606206	Advanced Power Electronics	3	0	0	3	3
7	EE606207	Design of Electrical Machines	3	0	0	3	3
8	EE606208	Analysis of Electrical Machines	3	0	0	3	3
9	EE606209	Analysis of Power Converters	3	0	0	3	3
10	EE606210	Modern Rectifiers and Resonant Converters	3	0	0	3	3

VERTICLE 3 – EMBEDDED SYSTEMS

S. No	Course Code	Course Title	L	T	P	No. of Contact Hours	C
1	EE606301	ARM Processors and Controllers	3	0	0	3	3
2	EE606302	Embedded Computing System Design	3	0	0	3	3
3	EE606303	Real Time Operating Systems	3	0	0	3	3
4	EE606304	Design of Embedded Systems	3	0	0	3	3
5	EE606305	Software for Embedded Systems	3	0	0	3	3

6	EE606306	Embedded Linux	3	0	0	3	3
7	EE606307	Embedded Control Systems Design	3	0	0	3	3
8	EE606308	Embedded Control for Electrical Drives	3	0	0	3	3
9	EE606309	Embedded System for Automotive Applications	3	0	0	3	3
10	EE606310	Embedded Product Development	3	0	0	3	3

VERTICLE 4 – CONTROL AND INTRUMENTATION

S. No	Course Code	Course Title	L	T	P	No. of Contact Hours	C
1	EE606401	Sensors and Actuators	3	0	0	3	3
2	EE606402	Industrial Instrumentation	3	0	0	3	3
3	EE606403	Medical Electronics	3	0	0	3	3
4	EE606404	Process Control	3	0	0	3	3
5	EE606405	Logic and Distributed Control System	3	0	0	3	3
6	EE606406	Industrial Data Networks	3	0	0	3	3
7	EE606407	Robotics and Automation	3	0	0	3	3
8	EE606408	Virtual Instrumentation	3	0	0	3	3
9	EE606409	Computer Control of Processes	3	0	0	3	3
10	EE606410	Instrumentation System Design	3	0	0	3	3

VERTICLE 5 – GREEN TRANSPORTATION

S. No	Course Code	Course Title	L	T	P	No. of Contact Hours	C
1	EE606501	Electric Vehicle Design	3	0	0	3	3
2	EE606502	Vehicle Dynamics and Control	3	0	0	3	3
3	EE606503	Modeling, Simulation and Control of Electric Vehicles	3	0	0	3	3
4	EE606504	Design of Motor and Power Converters for Electric Vehicles	3	0	0	3	3
5	EE606505	Design of Electric Vehicle Charging System	3	0	0	3	3
6	EE606506	Testing of Electric Vehicles	3	0	0	3	3
7	EE606507	Grid Integration of Electric Vehicles	3	0	0	3	3
8	EE606508	Fundamentals of Electric and Hybrid Vehicles	3	0	0	3	3
9	EE606509	Energy Storage and Management for Electric Vehicles	3	0	0	3	3
10	EE606510	Intelligent and Autonomous Vehicles	3	0	0	3	3

VERTICLE 6 – ELECTRICAL AND COMPUTATIONAL SCIENCES

S. No	Course Code	Course Title	L	T	P	No. of Contact Hours	C
1	CS640206	Object Oriented Programming Using Java	3	0	0	3	3

2		Operating systems	3	0	0	3	3
3	CS630202	Data Structures Using C++	3	0	0	3	3
4	EE606604	Data Analysis Using Python for Electrical Engineers	3	0	0	3	3
5	EE606605	Data Management for Smart Grid	3	0	0	3	3
6	EE606606	Communication and Data Security in Electrical Engineering	3	0	0	3	3
7	EE606607	Communication Protocols, Security and Protection for Smart Grid	3	0	0	3	3
8	EE606608	PLC Programming	3	0	0	3	3
9	EE606609	Machine Learning	3	0	0	3	3
10	EE606610	Optimization Studies in Electrical Systems	3	0	0	3	3

VERTICLE 7 – DIVERSIFIED COURSES

S. No	Course Code	Course Title	L	T	P	No. of Contact Hours	C
1	EE606701	Hybrid Energy Technology	3	0	0	3	3
2	EE606702	Energy Efficient Buildings	3	0	0	3	3
3	EE606703	Bluetooth Technology	3	0	0	3	3
4	EE606704	Deep Learning	3	0	0	3	3
5	EE606705	Edge Computing	3	0	0	3	3
6	EE606706	Fuzzy Systems and Applications	3	0	0	3	3
7	EE606707	Municipal Solid Waste Management (NPTEL)	3	0	0	3	3
8	EE606708	Augmented Reality	3	0	0	3	3
9	EE606709	MEMS Technology	3	0	0	3	3
10	EE606710	Nano Sensors and Its Applications	3	0	0	3	3

INSTITUTE ELECTIVE COURSES OFFERED BY DEPARTMENT OF EEE

S. No	Course Code	Course Title	L	T	P	No. of Contact Hours	C
1	EE607108	Conventional and Non-Conventional Sources of Energy	3	0	0	3	3
2	EE607109	Electric Vehicles	3	0	0	3	3
3	EE607207	Hybrid energy technology	3	0	0	3	3
4	EE607208	Smart Grid Technology	3	0	0	3	3
5	EE607209	Instrumentation Systems	3	0	0	3	3
6	EE607308	Industrial Automation	3	0	0	3	3
7	EE607309	Process Control and Automation	3	0	0	3	3
8	EE607310	Automotive Embedded Systems and Applications	3	0	0	3	3
9	EE607407	Hybrid and Electric Vehicle Engineering	3	0	0	3	3

10	EE607408	Fuzzy Logic Controllers	3	0	0	3	3

SEMESTER 1

IC610001 - PROFESSIONAL ENGLISH - I					
Course Category: Institute Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		2	**0**	**0**	**2**
COURSE OBJECTIVES:					
• To make the learners to communicate effectively and appropriately in real life situation. • To improve the student's vocabulary and to develop strong conversation and role play skills. • To grasp the substance and central idea from their communication skills.					
UNIT 1: INTRODUCTION TO FUNDAMENTALS OF COMMUNICATION					**6**
Technical English: Definition, Interpersonal, Intrapersonal, Verbal and Non-Verbal Communication. Speaking: Self-Introduction; Introducing a friend; Conversation – politeness strategies; Telephone Conversation. Reading: Reading longer technical texts. Writing: Paragraph writing, Short Report on an event (Fieldtrip etc.).					
UNIT 2: GRAMMATICAL COMPONENTS					**6**
Subject-Verb Agreement; Correct Usage: Noun; Pronoun; Modifiers; Articles; Prepositions; Prefixes and Suffixes, One Word Substations, Relative Pronouns, Sentence Structures, Phrase & Clause, Words and Phrases.					
UNIT 3: FORMS OF TECHNICAL WRITING					**6**
Letters: Complaint Letter, Placing an Order, Quotation, Enquiry letter, Agenda, Minutes of Meeting, Letter to the Editor, Technical Proposal: Writing of Proposal.					
UNIT 4: FORMS OF TECHNICAL READING					**6**
Developing Efficient Reading Skills - Types- Skimming, Scanning, Extensive reading, Intensive reading – predicting content – Interpretation – Inference from text - Implications- Critical reading, reading technical articles, advertisements and editorial of newspaper.					
UNIT 5: PRESENTATION STRATEGIES					**6**
Defining purpose, Audience & Locale, Organizing Contents, Preparing Audio-Video Aids, Body Language, Intonation: Stress & Rhythm, Presentation Techniques, Oral Presentation.					
TOTAL: 30 PERIODS					

COURSE OUTCOMES: At the end of the course, the student will be able to	
CO1	Write and speak clearly, read perceptively and think critically.
CO2	Understand the correct usage of English grammar in writing and speaking.
CO3	Write academic papers, essays and summaries using the process approach.
CO4	Read fluently through extensive reading.
CO5	Speak in English both in terms of fluency and comprehensibility.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	-	-	2	-	-	-	2	2	-	3	-	-
CO2	2	-	-	-	2	-	-	-	2	2	-	3	-	-
CO3	2	-	-	-	1	-	-	-	2	2	-	3	-	-
CO4	2	2	-	-	2	-	-	-	2	2	-	3	-	-
CO5	2	-	-	-	-	-	-	-	2	2	-	3	-	-

1- Low, 2 - Medium, 3 - High, '-' No Correlation

TEXT BOOKS:

1. Terk, Natasha. Professional Writing Skills. Gildan Media, Nov 2018.

2. Dwivedi, Amitabh. Communication skills for Professionals and Students. Notion Press. January 2019.

3. Lakshminarayan K. R, Murugavel. T. Managing Soft skills, New Delhi SCITECH Publication, (India) Pvt Ltd., 2010.

4. Ried Alison. Spoken English. Goodwill publishing house; First edition. 2019.

5. Carnegie Dale, The Quick and easy way to Effective Listening. Rupa; First edition. 2016.

REFERENCE BOOKS:

1. Bhaskara Rao, Varanasi. Communicative competence. BS Publications. BSP Books Pvt. Ltd., St ed. Edition, 2019.

2. Business Correspondence and Report Writing by Prof. R.C. Sharma & Krishna Mohan, Tata Mc Graw Hill & Co. Ltd., New Delhi. 2017.

3. Word Power Made Easy by Norman Lewis, W.R.Goyal Pub & Distributors; Delhi. Marcg 2015.

WEB RESOURCES:

1. Learning Library. https://www.education.com/resources/grammar/

2. Literacy Ideas. https://literacyideas.com

3. Reading Rockets. https://www.readingrockets.org

4. ESL Gold. https://eslgold.com

5. Basic English Speaking. https://basicenglishspeaking.com

IC610002 - MATRICES AND CALCULUS					
Course Category: Institute Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		2	**1**	**0**	**3**
COURSE OBJECTIVES:					

The objective of this course is to familiarize the students with basic elements of mathematics. It acquaints the students with standard concepts and tools that will serve as building blocks towards tackling more advanced level of mathematics that they are likely to find useful in their profession when employed in the firm/industry/corporation in public or private sector. This is specially designed for students to help them bring to speed with other students who have already had some training in mathematics at the higher secondary level.

UNIT 1: MATRICES	**12**

Matrices – Types of Matrices and operation including elementary row and column operation – Determinants (rules of computation) - Cayley-Hamilton theorem – Finding Inverse of a matrix using Cayley - Hamilton theorem – Eigen values and Eigen vectors – Diagonalization of matrix by Orthogonal transformation – Reduction of quadratic form to canonical form by orthogonal transformation – Nature of quadratic forms. Applications: Stretching of an elastic membrane and electrical networks.

UNIT 2: DIFFERENTIAL CALCULUS	**12**

Limits and Continuity – Concept of a derivative – Standard rules of differentiation – elementary trigonometric, logarithmic, and exponential differentiation – Implicit function differentiation –Taylors series expansion - Maxima and Minima for one variable. Application: Maxima and Minima of one variable.

UNIT 3: FUNCTIONS OF SEVERAL VARIABLES	**12**

Partial differentiation – Homogenous functions – Euler's theorem – chain rule - Total derivatives – change of variable – Jacobians– Properties of Jacobians – Partial differentiation of implicit functions – Taylor's series for functions of two variables. Applications: Maxima and Minima of functions of two variables and Lagrange's method of undetermined multipliers.

UNIT 4: INTEGRAL CALCULUS	**12**

Integration – definite and indefinite integral – standard rules of Integration –Integration by parts – Trigonometric integrals, inverse, Trigonometric substitution – Integration of

rational function by partial fraction – Improper Integrals. Applications: Moments and Centers of mass.

UNIT 5: MULTIPLE INTEGRALS **12**

Double Integration - Change of order of Integration – Area enclosed by plane curves – Triple Integrals – Volume of Solids – Change of variables in double and triple Integrals. Applications: Moments and Centers of mass, Moment of inertia.

TOTAL: 60 PERIODS

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

CO1	Find the Eigen values, Eigen vectors, canonical form and classify the nature of the quadratic form by matrix method.
CO2	Apply ordinary differentiation in maxima and minima and Solve ordinary differential equations by various methods.
CO3	Interpret the Jacobian and apply the Partial differential equations in Lagrange's method to find maxima and minima
CO4	Apply the concepts of integration and applications of indefinite integral by single Integration.
CO5	Analyse the change of variables in multiple Integration.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	-	-	1	-	-	-	-	-	3	-	-
CO2	3	2	2	1	-	1	-	-	-	-	-	3	-	-
CO3	3	2	2	2	-	-	-	-	-	-	-	3	-	-
CO4	3	2	2	2	-	1	-	-	-	-	-	3	-	-
CO5	3	2	-	2	-	-	-	-	-	-	-	3	-	-

1- Low, 2 - Medium, 3 - High, '-' No Correlation

TEXT BOOKS:

1. Kreyszig.E, "Advanced Engineering Mathematics", John Wiley and Sons, 10th Edition, New Delhi, 2016.

2. Grewal.B.S., "Higher Engineering Mathematics", Khanna Publishers, New Delhi, 44th Edition, 2018.

3. James Stewart, "Calculus: Early Transcendental", Cengage Learning, 8th Edition, New Delhi, 2015. [For Units II & IV – Sections 1.1, 2.2, 2.3, 2.5, 2.7 (Tangents problems only), 2.8, 3.1 to 3.6, 3.11, 4.1, 4.3, 5.1 (Area problems only), 5.2, 5.3, 5.4 (excluding net change theorem), 5.5, 7.1 – 7.4 and 7.8].

REFERENCE BOOKS:

1. Bali. N., Goyal. M. and Watkins. C., "Advanced Engineering Mathematics", Firewall Media (An imprint of Lakshmi Publications Pvt., Ltd.,), New Delhi, 7th Edition, 2009.
2. Jain. R.K. and Iyengar. S.R.K., "Advanced Engineering Mathematics", Narosa Publications, NewDelhi. 5th Edition, 2016.
3. Narayanan. S. and Manicavachagom Pillai. T. K., "Calculus" Volume I and II, S. Viswanathan Publishers Pvt. Ltd., Chennai, 2009.
4. Ramana. B.V., "Higher Engineering Mathematics", McGraw Hill Education Pvt. Ltd, New Delhi, 2016.

WEB RESOURCES:

1. Matrix. https://www.matrixres.com/en
2. Maxima and Minima for 1 variable functions.
https://www.youtube.com/watch?v=dksu5SZZ80A
3. Maxima and Minima of function of two variable.
https://www.youtube.com/watch?v=nfx0pdwsrLI
4. Improper Integrals. https://www.youtube.com/watch?v=kfv9h3c46CI
5. Integral Calculus – Double Integrals: Change of Variables.
https://www.youtube.com/watch?v=gQ-u_HlSKNk

IC610003 - ENGINEERING PHYSICS

Course Category: Institute Core	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To impart a strong foundation in the principles of Physics and make the students to apply them for engineering problems.

UNIT 1: ELASTIC PROPERTIES OF MATTER	**9**

Elasticity – Hooke's law – stress-strain diagram – elastic modulus – Poisson's ratio – torsional stress and deformations – twisting couple; applications: Torsion pendulum (theory and experiment) – bending of beams – bending moment – cantilever – determination of Young's modulus by uniform and non-uniform bending (qualitative).

UNIT 2: THERMAL PHYSICS	**9**

Heat Transfer -Conduction, Convection and Radiation (qualitative), Kinetic Theory of gases – distribution of velocities: Maxwell-Boltzmann law of distribution of velocities in an ideal

gas, Mean, RMS and most probable speeds; degrees of freedom, Law of equipartition of energy (No proof required), Specific heats of gases; Thermal conductivity and diffusion, application: Lee's Disc method (Theory and experiment) - Brownian motion and its significance. Introduction to thermo-electricity – Seebeck Effect, Peltier Effect, Thermoelectric devices, Thermistor, Newton's law of cooling.	
UNIT 3: ELECTROMAGNETISM	**9**
Coulomb's Law, Forces between charges, Electric field, Non-steady currents and charges, Faraday's laws of electromagnetic induction, concept of dipole, Ampere's circuital law, current loop as a dipole, torque on a dipole, Maxwell's field equations (derivation), Equation of continuity, displacement current. Electromagnetic wave equation (Derivation), Properties of plane electromagnetic waves: Poynting vector (derivation), production of electromagnetic waves, Applications: Hertz experiment.	
UNIT 4: QUANTUM MECHANICS	**9**
Concept of de Broglie's Matter waves – Derivation of wavelength of matter waves in different forms– Heisenberg's Uncertainty principle, Concept of Phase velocity and Group velocity (qualitative); Schrodinger's Time independent and dependent equation (derivation), Applications: Schrodinger's equation (qualitative treatment) – a) Particle in one dimensional rigid box b) Potential Barrier.	
UNIT 5: LASERS AND FIBRE OPTICS	**9**
Laser and its characteristics, Einstein's Coefficients (derivation), population inversion, meta stable state, types of pumping, lasing action, construction and working of He-Ne laser, CO_2 laser, Nd-YAG laser – Applications. Introduction to optical fiber, construction and working principle of an optical fiber, acceptance angle and numerical aperture, types of optical fibers – mode and propagation through step and graded index fibers, attenuation, Engineering, industrial and medical applications of optical fiber.	
TOTAL: 45 PERIODS	
COURSE OUTCOMES: At the end of the course, the student will be able to	
CO1	Apply and gain the knowledge to explain the elastic properties of matter.
CO2	Understand the knowledge on thermal conductivity of the materials and its significance.
CO3	Understand the basics of electrostatics, current electricity and the production of electromagnetic waves.
CO4	Understand the basic concept in quantum mechanics.

CO5	Understand the fundamental concepts of Optics and Laser for engineering applications

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	-	-	-	-	2	-	-	3	2	-	-
CO2	3	2	2	1	-	-	-	-	-	-	-	2	-	-
CO3	3	2	2	1	-	-	-	-	-	-	-	2	-	-
CO4	3	2	2	1	-	-	-	2	-	-	2	2	-	-
CO5	3	2	2	1	-	-	-	2	-	-	-	2	-	-

1- Low, 2 - Medium, 3 - High, '-' No Correlation

TEXT BOOKS:

1. R.K. Gaur and S. L. Gupta, Engineering Physics. DhanbatRai Publication, 2009.
2. E. Clark, Physics Electricity Magnetism & Waves, CBS Publishers & Distributors, 2005.
3. R. Murugeshan and Kiruthika Sivaprasath, Modern Physics, S. Chand Publishers, 18th Edition, 2019.

REFERENCE BOOKS:

1. Arthur Beiser, Shobit Mahajan and S. Rai Choudhury, Concepts of Modern Physics, 7th Edition, McGraw Hill, 2017.
2. D.K. Bhattacharya Poonam Tandon, Engineering physics, Oxford University Press, 2015.
3. Dattuprasad Ramanlal Joshi, Engineering Physics, Tata McGraw Hill Education Private Limited, 2010.
4. BN Sankar, SO Pillai, Engineering Physics, New Age International Private Limited, 2015.

WEB RESOURCES:

IC610004 - ENGINEERING CHEMISTRY

Course Category: Institute Core	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To impart a strong foundation in the principles of chemistry and make the students to apply them for engineering problems.

UNIT 1: INDUSTRIAL CHEMICALS **9**

Introduction – Preparation and industrial applications of ammonium chloride, ammonium nitrate, ammonium sulfate, chromic acid, acrylonitrile, caprolactam, cellulose acetate,

diethyl ether, glycerin, melamine (from urea). Rocket propellants: Definition, characteristics of good propellants, classification and advantages of propellants.	
UNIT 2: ENERGY SCIENCES	**9**
Battery technology – Fundamentals of primary cells, rechargeable batteries, Ni-Cd battery, Ag_2O-Zn alkaline battery, lead-acid storage cells; Fuel cells – hydrogen–oxygen fuel cell, Solid oxide fuel cells (SOFC): principles, applications, advantages/disadvantages. Conventional Fuels – Types of fuels, calorific value, processing and refining of petroleum, liquid fuels - synthesis of petrol by Bergius process - Knocking and anti-knocking agents, Octane and Cetane values, cracking of crude oil - catalytic cracking, Nuclear Energy - nuclear reactor – working principle (conventional energy), Non - conventional sources of energy: Solar energy (principles), Wind energy- Applications. Field study of non-conventional sources of energy.	
UNIT 3: CORROSION	**9**
Definition, dry (or chemical) corrosion, wet (or electrochemical) corrosion and their mechanisms; Types of electrochemical corrosion, (differential aeration, galvanic). Typical electrochemical corrosion like pitting, inter-granular, soil, and waterline corrosion. Factors affecting corrosion. Protection of corrosion – Sacrificial Anodic Protection (SAP) method and Impressed Current Cathodic Protection method (ICCP). Protective coatings – Paints: constituents and function.	
UNIT 4: INSTRUMENTAL TECHNIQUES	**9**
Beer-Lambert's law–Flame photometry – principle – instrumentation (block diagram only) – Estimation of sodium by flame photometry – Atomic Absorption Spectroscopy (AAS) – principles – instrumentation (block diagram only) – estimation of nickel by atomic absorption spectroscopy. Thermal methods of analysis: Thermogravimetric analysis (TGA) - principles, instrumentation (block diagram only), application of TGA to decomposition of calcium oxalate system, Differential thermal analysis (DTA) - principles, instrumentation (block diagram only), endothermic curves, exothermic curves, DTA thermogram analysis of pure sulfur.	
UNIT 5: PHASE RULE AND ALLOYS	**9**
Phase Rule: Phase, component, degree of freedom, phase rule applications to one component system-water system. Condensed phase rule, two component system: lead-silver system. Alloys: Importance of making alloys, types of alloys: ferrous and nonferrous alloys. Nichrome, carbon steel, duralumin, monel metal. Powder metallurgy, Heat treatment of	

alloys.

TOTAL: 45 PERIODS

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

CO1: Apply the knowledge in chemical industries in the manufacture of chemicals.

CO2: Differentiate the various sources of energy and its applications.

CO3: Get awareness about corrosion and its protection techniques.

CO4: Know the usage of analytical devices for industrial processes.

CO5: Understand the basic concepts of phase rule in the manufacture of alloys and its applications.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	-	-	3	-	-	-	2	2	-	-
CO2	3	2	2	1	-	-	3	-	-	-	-	2	-	-
CO3	3	2	2	1	-	-	3	-	-	-	-	2	-	-
CO4	3	2	2	1	-	-	3	-	-	-	-	2	-	-
CO5	3	2	2	1	-	-	3	-	-	-	2	2	-	-

1- Low, 2 - Medium, 3 - High, '-' No Correlation

TEXT BOOKS:

1. Vairam and Suba Ramesh, Engineering Chemistry-I, Wiley India Pvt. Ltd, 2014.

2. Shashi Chawla, A Text Book of Engineering Chemistry, Dhanpat Rai & Co., 2015.

3. C. V. Agarwal, C. P. Murthy, A. Naidu, "Chemistry of Engineering Materials", Wiley India, 5th Edition, 2013.

4. Engineering Chemistry by Prasanth Rath, Cengage Learning, 2015.

REFERENCE BOOKS:

1. Puri, Sharma, Pathania, Principles of Physical Chemistry, Vishal Publishing Co., 2015.

2. B. Siva Shankar, "Engineering Chemistry", Tata Mc Graw Hill Publishing Limited, 3rd Edition, 2015.

3. P.Mani, K.N.Mishra, "Chemistry of Engineering Materials", Cengage Learning, 3rd Edition, 2015.

WEB RESOURCES:

1. Industrial Chemistry.
https://www.studocu.com/in/document/sardar-patel-university/industrial chemistry/industrial-chemistry-lecture-notes-1-18/20483178.

2. Energy-Engineering.

http://www.freebookcentre.net/chemical-books-download/Energy-Engineering-Lecture-Notes.html

3. Corrosion Science.
https://www.lkouniv.ac.in/site/writereaddata/siteContent/20200325190322943 4ranvijay_Corrosion_Science.pdf

4. Instrumental Methods of Analysis.
https://www.sathyabama.ac.in/sites/default/files/course-material/2020-10/SCY2.pdf

5. Engineering Chemistry. https://ccsuniversity.ac.in/bridge-library/pdf/Engg-AG-Engg-Chem-2nd-sem-subodh-Lecture-5.pdf

CS610005 - PROBLEM SOLVING AND 'C' PROGRAMMING					
Course Category: Institute Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To understand the basics of algorithmic problem solving.
- To develop C Programs using basic programming constructs
- To develop C programs using arrays and strings.
- To develop modular applications in C using functions and pointers
- To develop applications in C using structures and union

UNIT 1: COMPUTATIONAL THINKING AND PROBLEM SOLVING	**9**

Software and its types – Software Life Cycle - Algorithm and Flowchart for problem solving with Sequential Logic Structure, Decisions and Loops. Imperative languages: Introduction to imperative language; syntax and constructs of a specific language (ANSI C).

UNIT 2: BASICS OF C PROGRAMMING	**9**

Introduction to programming paradigms – Applications of C Language - Structure of C program - C programming: Data Types - Constants – Enumeration Constants - Keywords – Operators: Precedence and Associativity - Expressions - Input/Output statements- Assignment statements – Decision making statements - Switch statement - Looping statements – Preprocessor directives - Compilation process.

UNIT 3: ARRAYS AND STRINGS	**9**

Introduction to Arrays: Declaration, Initialization – One dimensional array – Two

dimensional arrays - String operations: length, compare, concatenate, copy – Selection sort, linear and binary search.

UNIT 4: FUNCTIONS AND POINTERS **9**

Functions- Defining function- Accessing a function- Function prototypes- Passing arguments to a functions- Passing arrays to a function- Passing Pointers to function- Recursion – Dynamic memory allocation - malloc, calloc, realloc-Pointers – Pointer operators – Pointer arithmetic – Arrays and pointers – Array of pointers.

UNIT 5: STRUCTURES AND UNION **9**

Structures – Declaration –Nested Structures- Structures and Functions – Arrays of Structures – Pointers to structures – Types of - Unions – Bit-fields.

Case Studies:

1. Print Characters without using format specifiers
2. Check the given IP address is valid or not
3. Storage management using Structure and Union

TOTAL: 45 PERIODS

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

CO1: Develop algorithmic solutions to simple computational problems.

CO2: Solve simple applications in C using basic constructs.

CO3: Design and implement applications using arrays and strings.

CO4: Apply the usage of functions and Pointers in programming

CO5: Solve applications in C using structures and union.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	3	2	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	2	3	-	3	-	-	-	-	-	-	-	-	-
CO4	-	2	3	-	3	-	-	-	-	-	-	2	-	-
CO5	-	2	3	3	-	-	-	-	-	-	-	2	-	-

1- Low, 2 - Medium, 3 - High, '-' No Correlation

TEXT BOOKS:

1. E Balaguruswamy, Programming in ANSI C, Tata McGraw-Hill, 2018

2. ReemaThareja, "Programming in C", Oxford University Press, Second Edition, 2016.

3. Kernighan, B.W and Ritchie, D.M, "The C Programming language", Second Edition, Pearson Education, 2015.

4. Allen B. Downey, “Think Python: How to Think like a Computer Scientist”, 2nd Edition, O’Reilly Publishers, 2016.

5. Karl Beecher, “Computational Thinking: A Beginner, Guide to Problem Solving and programming”, 1st Edition, BCS Learning & Development Limited, 2017.

REFERENCE BOOKS:

1. Paul Deitel and Harvey Deitel, “C How to Program with an Introduction to C++”, Eighth edition, Pearson Education, 2018.

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

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

4. Yashwant Kanetkar, Let us C, 17th Edition, BPB Publications, 2020.

5. Pradip Dey, Manas Ghosh, “Computer Fundamentals and Programming in C”, Second Edition, Oxford University Press, 2013.

6. Byron S. Gottfried, “Schaum’s Outline of Theory and Problems of Programming with C”, McGraw-Hill Education, 1996.

7. Anita Goel and Ajay Mittal, “Computer Fundamentals and Programming in C”, 1st Edition, Pearson Education, 2013.

WEB RESOURCES:

1. Computational Thinking. https://www.youtube.com/watch?v=reUOojtbU3A
2. C Programming. https://www.youtube.com/watch?v=3QiItmIWmOM
3. Arrays and Strings. https://www.youtube.com/watch?v=3ZgDx-0oGQQ
4. Function Pointers in C. https://www.youtube.com/watch?v=qaszuaFXRTA
5. Structures & Union in C. https://www.youtube.com/watch?v=jjNs_x7rlQk

ME610006 - ENGINEERING GRAPHICS WITH CAD					
Course Category: Institute Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		2	**0**	**2**	**3**

COURSE OBJECTIVES:

To develop in students, graphic skills for communication of concepts, ideas and design of engineering products and expose them to existing national standards related to technical drawings and computer aided drafting.

CONCEPTS AND CONVENTIONS (Not for Examination)	**2**
Importance of graphics in engineering applications – Use of drafting instruments – BIS conventions and specifications – Size, layout and folding of drawing sheets – Lettering and dimensioning.	
UNIT 1: ORTHOGRAPHIC PROJECTION	**12**
Introduction to orthographic projection, drawing orthographic views of objects from their isometric views. Orthographic projections of points lying in four quadrants. Orthographic projection of lines parallel and inclined to one and both the planes.	
UNIT 2: PROJECTION OF PLANES AND SOLIDS	**12**
Orthographic projection of planes inclined to any one of the plane. Projections of simple solids - axis perpendicular to HP, axis perpendicular to VP and axis inclined to horizontal planes only.	
UNIT 3: PROJECTION OF SECTIONED SOLIDS & DEVELOPMENT OF SURFACES	**12**
Introduction to sectioning of solids - Section planes perpendicular to one plane and parallel to another plane, section plane inclined to horizontal plane. Introduction to development of surfaces - Development of prisms, pyramids and cylindrical & conical surfaces.	
UNIT 4: ISOMETRIC PROJECTION	**12**
Introduction to Isometric projection and isometric views of different planes and simple solids - Introduction to perspective projection.	
UNIT 5: INTRODUCTION TO COMPUTER AIDED DRAFTING	**10**
Computer screen, layout of the software, standard tool bar / menu and description of most commonly used tool bars, and navigational tools. Co-ordinate system and reference planes HP, VP, RPP & LPP of 2D/3D environment. Selection of drawing sheet size and scale. Commands and creation of Lines, coordinate points, axes, poly-lines, square, rectangle, polygons, circle, ellipse, text, move, copy, off-set, mirror, rotate, trim, extend, break, chamfer, fillet, curves, constraints viz., tangency, parallelism, inclination and perpendicularity.	
TOTAL: 60 PERIODS	
COURSE OUTCOMES: At the end of the course, the student will be able to	
CO1: Illustrate the fundamentals of engineering drawing and draw orthographic projections of points and lines.	

CO2: Draw the orthographic projections of planes and simple solids.

CO3: Draw the orthographic projections of sectioned solid and development of surfaces.

CO4: Sketch the isometric view of simple solids.

CO5: Determine to determine the features of CAD Software

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	-	-	-	-	-	-	-	-	2	-	-
CO2	3	2	2	-	-	-	-	-	-	-	-	2	-	-
CO3	3	3	2	-	-	-	-	-	-	-	-	2	-	-
CO4	3	3	3	-	-	-	-	-	-	-	-	2	-	-
CO5	3	3	3	-	3	-	-	-	-	-	-	2	-	-

1- Low, 2 - Medium, 3 - High, '-' No Correlation

TEXT BOOKS:

1. Bhatt N.D. and Panchal V.M., "Engineering Drawing", Charotar Publishing House 53rd Edition, 2019.

2. Natrajan K.V., "A Text Book of Engineering Graphics", Dhanalakshmi Publishers, Chennai, 2018.

REFERENCE BOOKS:

1. Basant Agarwal and Agarwal C.M., "Engineering Drawing", McGraw Hill, 2nd Edition, 2019.

2. Gopalakrishna K.R., "Engineering Drawing" (Vol. I &II combined), Subhas Publications, Bangalore, 27thEdition, 2017.

3. Shah M.B., and Rana B.C., "Engineering Drawing", Pearson Education India, 2nd Edition, 2009.

4. Venugopal K. and Prabhu Raja V., "Engineering Graphics", New Age International Publishers; Fifteenth edition (1 July 2018)

WEB RESOURCES:

1. Introduction to Engineering Graphics.

https://www.youtube.com/watch?v=ANEvQyt3PnU

2. Drawing Instruments. https://www.youtube.com/watch?v=-W7tH49dBLw&t=36s

IP610101 - PHYSICS & CHEMISTRY LABORATORY					
Course Category: Institute Core	**Course Type: Practical**	**L**	**T**	**P**	**C**

		0	**0**	**3**	**1.5**

COURSE OBJECTIVES:		

To enrich the student's experimental knowledge in the Physics and Chemistry, and train them to handle independently the instruments and chemicals.

LIST OF EXPERIMENTS IN PHYSICS

1. Laser parameter, particle size and acceptance angle
2. Velocity of ultrasonic waves – Ultrasonic Interferometer
3. Young's Modulus of the material – Uniform and Non-Uniform bending
4. Thermal conductivity of bad conductor – Lee's disc method
5. Hysteresis – Magnetometer method
6. Bandgap determination of a semiconductor – P.O Box Method

LIST OF EXPERIMENTS IN CHEMISTRY

1. Determination of total hardness in water sample using EDTA.
2. Estimation of carbonate and non-carbonate hardness of water.
3. Determination of Dissolved Oxygen in Water
4. Conductometric Precipitation Titration.
5. Potentiometric Titration (Redox).
6. Estimation of copper in brass by EDTA method.

TOTAL: 45 PERIODS

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

CO1: Measure the wavelength of laser light and evaluate the particle size using it.

CO2: Understand the production and properties of ultrasonic waves

CO3: Analyse the mechanical, thermal and magnetic properties of materials

CO4: Estimate the amount of total and carbonate, non-carbonate hardness, dissolved oxygen in the given sample of hard water sample.

CO5: Determine the conductivity and potentiometric analysis for the given solution by titration method.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	-	-	-	1	-	3	2	-	2	-	-
CO2	3	2	2	-	-	-	1	-	3	2	-	2	-	-
CO3	3	2	2	-	-	-	1	-	3	2	-	2	-	-
CO4	3	2	2	-	-	-	1	-	3	2	-	2	-	-
CO5	3	2	2	-	-	-	1	-	3	2	-	2	-	-

1- Low, 2 - Medium, 3 - High, '-' No Correlation

INSTITUTE MANDATORY COURSE

NATIONAL CADET CORPS (NCC) / NATIONAL SERVICE SCHEME (NSS) / NATIONAL SPORTS ORGANIZATION (NSO)

Course Objective(s):

To enable the students to gain knowledge about NCC/NSS/NSO and put the same into practice

Course Outcomes: (COs)

At the end of this course, the students will be able to

Imbibe in their minds related to the concepts and benefits of NCC/NSS/NSO and make them practice the same.

NATIONAL CADET CORPS (NCC):

Any student enrolling as a member of National Cadet Core (NCC) will have to attend sixteen parades out of twenty parades each off our periods over a span of academic year. Attending eight parades in first semester will qualify a student to earn the credits specified in the curriculum. Grading shall be done based on punctuality, regularity in attending the parades and the extent of active involvement.

NATIONAL SERVICE SCHEME (NSS):

A student enrolling as member of NSS will have to complete 60hours of training / social service to be eligible to earn the credits specified in the curriculum. Grading shall be done by the faculty member handling the course based on punctuality, regularity in attending the classes and the extent of active involvement.

NATIONAL SPORTS ORGANIZATION (NSO):

Each student must select one of the following games/sports events and practice for one hour per week. An attendance of 75% is compulsory to earn the credits specified in the curriculum. Grading shall be done by the faculty member handling the course based on punctuality, regularity in attending the classes and the extent of active involvement. List of games/sports: Basket Ball, Football, Volley Ball, Ball Badminton, Cricket, Throw- ball, Track events, Field

events or any other game with the approval of faculty member.

SEMESTER 2

<table>
<tr><th colspan="6">IC620008 - PROFESSIONAL ENGLISH - II</th></tr>
<tr><td colspan="2">Course Category: Institute Core</td><td colspan="2">Course Type: Theory with Practical Component</td><td colspan="2"><table><tr><th>L</th><th>T</th><th>P</th><th>C</th></tr><tr><td>2</td><td>0</td><td>2</td><td>3</td></tr></table></td></tr>
<tr><td colspan="2">COURSE OBJECTIVES:</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td colspan="6">The objective of the course is to make the students to possess the basic workplace skills. It makes the students to empower the learners of Engineering and Technology to attain the key employability skills.</td></tr>
<tr><td colspan="5">UNIT 1: MAKING COMPARISONS</td><td>6</td></tr>
<tr><td colspan="6">Listening: Listening and Responding to complaints, Listening to problem, Evaluating listening: Advertisement, Product/Description, Listening and Filling a form. Speaking: Offering solution, Group Discussion Reading: Reading aloud, Reading Advertisements, User Manuals. Writing: Professional Emails, Writing a paragraph on Motivational ideas.</td></tr>
<tr><td colspan="5">UNIT 2: PERSUASIVE COMMUNICATION</td><td>6</td></tr>
<tr><td colspan="6">Listening: Listening to famous speeches, Listening to a product launch, Watching movie scenes or documentaries, Depicting a technical problem. Speaking: Making a Short Speeches- Formal: Welcome Speech and Vote of Thanks, Informal: Farewell Speech, Graduation Speech. Reading: Stress and Intonation-Voice Modulation. Writing: Dialogue writing, writing opinion pieces (book review, Food review, Film review).</td></tr>
<tr><td colspan="5">UNIT 3: DIGITAL COMPETENCE</td><td>6</td></tr>
<tr><td colspan="6">Listening: Listening to Interview, Gap Filling exercises, Listening to Panel Discussions. Speaking: Interview with subject specialists, participating in a meeting: Face to Face and Online, Creating Vlogs (subject related). Reading: Excerpts from literary Texts, News Reports, Writing: Preparing first draft of short assignments, Checklists.</td></tr>
<tr><td colspan="5">UNIT 4: CREATIVITY AND IMAGINATION</td><td>6</td></tr>
<tr><td colspan="6">Listening: Listening comparison based on news reports, Documentaries. Speaking: Interviewing, Presenting on Oral Report, Mini presentation on selected topics. Reading: Essays on creativity and imagination (subject based). Writing: Recommendation, Reports and Technical and Scientific Articles.</td></tr>
</table>

UNIT 5: WORKPLACE COMMUNICATION AND BASIC ACADEMIC WRITING	6

Listening: Listening to the Presentation, Formal Job Interview, Informal Interview for feature writing, Short videos (conference meeting). Speaking: Short academic presentation using power point presentation, Debate. Reading: Product profiles, Circulars, Scripts reading. Writing: Writing an introduction, Paraphrasing and Job Application: Cover Letter and Resume.

TOTAL: 30 PERIODS

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

CO1: Improve their employability skills and to develop their competence and competitiveness.

CO2: Solve the problems in communicative contexts using analytical thinking skills.

CO3: Create formal reports and proposals cohesively, creatively and flawlessly.

CO4: Think in innovative ways to solve issues in the work place by enhancing the creativity of the students.

CO5: Improve their competence in the use of English with particular reference to the workplace situations.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	2	-	-	-	-	-	-	2	2	-	3	-	-
CO2	2	2	-	-	-	-	-	-	2	2	-	3	-	-
CO3	1	2	-	-	-	-	-	-	2	2	-	3	-	-
CO4	2	2	-	-	-	-	-	-	2	2	-	3	-	-
CO5	1	2	-	-	-	-	-	-	2	2	-	3	-	-

1- Low, 2 - Medium, 3 - High, '-' No Correlation

TEXT BOOKS:

1. English for Engineers and Technologist, Orient Blackswan Pvt. Ltd, Department of English, Anna University, 2020.

2. Dr. Veena Selvam, Dr. Sujatha Priyadharshini, Dr. Deepa Mary Francis, Dr. KN. Sobha and Dr. Lourdes Joevani, Department of English, Anna University, English for Science and Technology, Cambridge University Press, 2021.

3. Muralikrishna M, Sunitha Mishra. Communication skill for Engineers. Second Edition. Pearson, India. February 2011.

4. Yates, Jean. English Conversation. Premium Third Edition, McGraw-Hill Education, July 2020.

5. McCarthy, Michael. O'Dell Felicity. English Collocations in Use. Second Edition, Cambridge, University Press, July 2017.

REFERENCE BOOKS:

1. Raman, Meenatchi, Sharma. Sangeetha. Professional English. Oxford University press, New Delhi. 2019.
2. Communication skills for professionals and students by Dr.Amitabh Dwivedi, Notion Press, 1st Edition. 2019.
3. Cullen, Pauline, Vocabulary for IELTS Advanced. Cambridge English, Jan 2016.

WEB RESOURCES:

1. Literacy Ideas. https://literacyideas.com
2. Reading Rockets. https://www.readingrockets.org
3. Learn English Online. https://eslgold.com

IC620009- TRANSFORMS AND PARTIAL DIFFERENTIAL EQUATIONS

Course Category: Institute Core	Course Type: Theory	L	T	P	C
		2	1	0	3

COURSE OBJECTIVES:

The objective of this course is to familiarize the students with basic elements of mathematics. It acquaints the students with standard concepts and tools that will serve as building blocks towards tackling more advanced level of mathematics portion in public or private sector. This is specially designed for students to help them bring to speed with other students who have already had some training in mathematics at the higher secondary level.

UNIT 1: FOURIER SERIES **12**

Fourier series – Dirichlet's conditions – General Fourier series –Fourier series of periodic functions with different periods - Fourier series of Odd functions – Fourier series of even functions – Half range Fourier sine series – Half range Fourier cosine series – Root mean square value - Parseval's identity – Harmonic Analysis

UNIT 2: PARTIAL DIFFERENTIAL EQUATIONS AND ITS APPLICATIONS **12**

Formation of partial differential equations – the four standard forms – Equations of the form f (p,q) = 0 – Clairaut's equation - Solution of Lagrange's linear partial differential equations Pp+Qq = R.

Solutions of one dimensional wave equation – One dimensional equation of heat conduction – Steady state solution of two-dimensional equation of heat conduction (Insulated edges

excluded).

UNIT 3: LAPLACE TRANSFORM **12**

Laplace transform – Conditions for existence – Transform of elementary functions –Basic properties – Transform of derivatives and integrals – Transform of unit step function and impulse functions – Transform of periodic functions. Definition of Inverse Laplace transform as contour integral – Convolution theorem (excluding proof) – Application of Laplace transformation.

UNIT 4: FOURIER TRANSFORMS **12**

Fourier integral theorem (without proof) – Fourier transform pair – Sine and Cosine transforms – Properties – Transforms of simple functions – Convolution theorem– Parseval's identity- Application of Fourier transforms.

UNIT 5: Z -TRANSFORMS AND DIFFERENCE EQUATIONS **12**

Z-transforms - Elementary properties – Inverse Z-transform – Convolution theorem - Formation of difference equations – Application of Z-transforms.

TOTAL: 60 PERIODS

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

CO1: Classify the fundamental knowledge of the Fourier series.

CO2: Apply PDE in various Engineering fields.

CO3: Apply the knowledge of Laplace transform which can describe real life phenomena.

CO4: Classify the fundamentals of the Fourier transforms.

CO5: Distinguish the fundamental knowledge's of the Z-Transforms

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	-	-	-	-	-	-	-	3	-	-
CO2	3	2	2	2	-	-	-	-	-	-	-	3	-	-
CO3	3	2	2	2	1	-	-	-	-	-	-	3	-	-
CO4	3	2	2	2	1	-	-	-	-	-	-	3	-	-
CO5	3	2	2	2	1	-	-	-	-	-	-	3	-	-

1- Low, 2 - Medium, 3 - High, '-' No Correlation

TEXT BOOKS:

1. Grewal, B.S, 'Higher Engineering Mathematics' 47th Edition, Khanna publishers Delhi, 2016.

2. Bali.N.P and Manish Goyal 'Transforms and partial differential Equations', Second Edition, Laxmi Publications(P) Ltd., 2011. (For units 2,3,4,5)

REFERENCE BOOKS:
1. Ramana.B.V. 'Higher Engineering Mathematics' Tata Mc-GrawHill Publishing Company limited, New Delhi, 2007. 2. Glyn James, 'Advanced Modern Engineering Mathematics', Third edition-Pearson Education, 2007. 3. Erwin Kreyszig 'Advanced Engineering Mathematics', Eighth edition - Wiley India, 2007. 4. T.Veerarajan, "Engineering Mathematics", Tata-Mc Graw Hill Publishing Pvt. Ltd., New Delhi, 2008.
WEB RESOURCES:
1. Fourier Transforms. https://blogs.ed.ac.uk/mnaylor/2020/10/13/web-resources-on-fourier-transforms/ 2. Applications of PDEs in Real Life. https://www.youtube.com/watch?v=jo8EO2KxLmw 3. Intro to the Laplace Transform & Three Examples. https://www.youtube.com/watch?v=KqokoYr_h1A

IC620011- SEMI CONDUCTOR PHYSICS					
Course Category: Institute Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**
COURSE OBJECTIVES:					
To provide exposure and knowledge in the Semiconductor Physics					
UNIT 1: CRYSTAL STRUCTURE					**9**
Crystal– classification-calculation of number of atoms per unit cell–atomic radius coordination number– packing factor for simple cubic (SC), Body Centered cubic (BCC), Face centered cubic (FCC) and Hexagonal closed packed (HCP) structures – polymorphism and allotropy–crystal defects: point, line and surface defects; Applications: Bragg's law, Powder X-ray diffractometer.					
UNIT 2: ELECTRONIC MATERIALS					**9**
Free electron theory, Density of states and energy band diagrams, Kronig-Penny model to introduce origin of band gap, Energy bands in solids, E-k diagram, Direct and indirect bandgaps, Types of electronic materials: metals, semiconductors, and insulators, Occupation probability, Fermi level, Effective mass, Phonons.					
UNIT 3: SEMICONDUCTORS					**9**
Intrinsic and extrinsic semiconductors, Dependence of Fermi level on carrier-concentration					

and temperature (equilibrium carrier statistics), Carrier generation and recombination, Carrier transport: diffusion and drift, p-n junction, Metal-semiconductor junction (Ohmic and Schottky), Semiconductor materials of interest for optoelectronic devices: transistors and MOSFETs–LED, Laser, Photodetectors.

UNIT 4: MEASUREMENTS & ENGINEERED SEMICONDUCTOR MATERIALS | **9**

Four-point probe and van der Pauw measurements for carrier density, resistivity, and hall mobility; Hot-point probe measurement, capacitance-voltage measurements, parameter extraction from diode I-V characteristics, Deep Level Transient Spectroscopy (DLTS), band gap by UV-Vis spectroscopy, absorption/transmission. Density of states in 2D, 1D and 0D (qualitatively), Practical examples of low-dimensional systems (quantum wells, wires, and dots).

UNIT 5: INTRODUCTION TO SOLARCELLS | **9**

Solar radiation–solar spectrum–solar energy–photovoltaic effect–fundamentals of solar cells–current–voltage characteristics– conversion efficiency and power. Types of solar cells – silicon solar cells – thin film solar cells – dye sensitized solar cells. Cell to Module–Applications: Fabrication of solar panels–solar water heating– solar concentrators.

TOTAL: 45 PERIODS

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

CO1: Apply the knowledge gained to identify crystal structures and the significance of crystal effects.

CO2: Differentiate the types of electronic materials and the origin of bands.

CO3: Execute the semiconductor Physics towards optoelectronic devices

CO4: Relate the various measurement techniques for engineering applications

CO5: Implement the working parameters of a solar cell and the technologies that are used to harness the power of solar energy

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	-	-	-	-	-	-	-	-	3	-	-
CO2	3	2	2	1	-	-	-	-	-	-	-	3	-	-
CO3	3	2	2	1	-	-	-	-	-	-	-	3	-	-
CO4	3	2	2	1	-	-	-	-	-	-	-	3	-	-
CO5	3	2	2	1	-	-	-	-	-	-	-	3	-	-

1- Low, 2 - Medium, 3 - High, '-' No Correlation

TEXT BOOKS:

1. Joachim Piprek, Semiconductor Optoelectronic devices, Introduction to Physics and simulation, 2013.

2. R. Murugeshan and Kiruthika Sivaprasath, Modern Physics, S. Chand Publishers, 18th Edition, 2019

3. Arvind Shah, Solar Cells and modules 2020.

4. Roberto Fornari, Single Crytals of Electronic Materials: Growth and Properties, 2018

5. YuriyPoplavko, Electronic Materials: Principles and Applied Science, 2018

REFERENCE BOOKS:

1. Sergio M Resande, Introduction to Electronic Materials and Devices, Springer Link, First Edition, 2022.

2. Arthur Beiser, ShobitMahajan and S. Rai Choudhury, Concepts of Modern Physics, 7th edition, McGraw Hill, 2017

3. Fundamentals of Solar Astronomy by Arvind Bhatnagar and William Livingston, latest edition, World scientific.

4. Atul Tiwari, Rabah Boukherroub, Maheshwar Sharon, Solar Cell Nanotechnology, 2013.

WEB RESOURCES:

1. Crystal Structure. https://en.wikipedia.org/wiki/Crystal_structure

2. FCC. BCC and HCP Metals. http://che.uri.edu/course/che333/Structure.pdf

3. Semiconductors. https://byjus.com/jee/semiconductors/#:~:text=What%20are%20Semiconductors%3F,such%20as%20germanium%20or%20silicon.

4. Introduction to photovoltaic solar cells. https://metsolar.eu/blog/introduction-photovoltaics-solar-cells/

CS620013 - FUNDAMENTALS OF ARTIFICIAL INTELLIGENCE

Course Category: Institute Core	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the various characteristics of Intelligent agents
- To learn the different search strategies in AI
- To learn to represent knowledge in solving AI problems
- To understand the different ways of designing software agents
- To know about the various applications of AI.

UNIT 1: INTRODUCTION	**6**
Introduction about AI–Definition - Future of Artificial Intelligence – Goals of Artificial Intelligence-Advantages of Artificial Intelligence-Disadvantages of Artificial Intelligence-Application of AI-History of Artificial Intelligence-Types of Artificial Intelligence.	
UNIT 2: PROBLEM SOLVING METHODS	**6**
Problem-solving agents-Search Algorithm Terminologies-Properties of Search Algorithms-Types of search algorithms-Problem solving Methods - Local Search Algorithms and Optimization Problems - Searching with Partial Observations.	
UNIT 3: KNOWLEDGE REPRESENTATION	**6**
Types of knowledge in AI– Issues in knowledge representation -Logic Representation-Propositional Logic – Unification – Forward Chaining-Backward Chaining – Resolution – Knowledge Representation - Ontological Engineering-Categories and Objects – Events - Mental Events and Mental Objects.	
UNIT 4: SOFTWARE AGENTS	**6**
User agents (personal agents)-Monitoring-and-surveillance (predictive) agents-Networking and communicating agents-Software development agents -Security agents-Collaborative Agents-Mobile Agents-Agent-oriented programming (AOP).	
UNIT 5: APPLICATIONS	**6**
AI Application in E-Commerce- Education- Lifestyle-Navigation-Robotics-Healthcare-Agriculture-Gaming-Chatbots-Finance.	
TOTAL: 30 PERIODS	
COURSE OUTCOMES: At the end of the course, the student will be able to	
CO1: Use appropriate search algorithms for any AI problem	
CO2: Understand various problems solving methods	
CO3: Identify the apt agent strategy to solve a given problem	
CO4: Understand the concept of software agents	
CO5: Recognize the use of AI in various real time applications	

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	-	-	-	-	-	-	-	1	-	-	-	-
CO2	1	2	-	-	-	-	-	-	-	-	-	1	-	-
CO3	1	1	-	-	1	-	-	-	-	-	-	-	-	-
CO4	2	1	-	-	2	-	-	-	-	1	-	1	-	-
CO5	2	-	-	-	1	-	-	-	-	2	-	1	-	-

1- Low, 2 - Medium, 3 - High, '-' No Correlation
TEXT BOOKS:
1. S. Russell and P. Norvig, "Artificial Intelligence: A Modern Approach‖, Prentice Hall, Third Edition, 2009. 2. I. Bratko, Prolog: Programming for Artificial Intelligence‖, Fourth edition, Addison Wesley Educational Publishers Inc., 2011.
REFERENCE BOOKS:
1. M. Tim Jones, Artificial Intelligence: A Systems Approach(Computer Science)‖, Jones and Bartlett Publishers, Inc.; First Edition, 2008 2. Nils J. Nilsson, The Quest for Artificial Intelligence‖, Cambridge University Press, 2009. 3. William F. Clocksin and Christopher S. Mellish, Programming in Prolog: Using the ISO Standard, Fifth Edition, Springer, 2003. 4. Gerhard Weiss, Multi Agent Systems‖, Second Edition, MIT Press, 2013. 5. David L. Poole and Alan K. Mackworth, Artificial Intelligence: Foundations of Computational Agents‖, Cambridge University Press, 2010.
WEB RESOURCES:
1. Introduction and basics of Artificial Intelligence. https://www.youtube.com/watch?v=61RbzGBpBIs 2. Artificial Intelligence https://www.youtube.com/watch?v=CXtN2fik8L0 https://www.youtube.com/watch?v=2iHaSVEadiI https://www.youtube.com/watch?v=Oth_jnB5lOA

ME620015 - BASIC ENGINEERING					
Course Category: Institute Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**
COURSE OBJECTIVES:					
To attain the knowledge about basic construction materials, surveying, electrical, manufacturing processes and computer generations.					
UNIT 1: CONSTRUCTION MATERIALS & SURVEYING					**9**
Construction Materials – Properties, Types and uses of Stone, Bricks, Sand, Cement, Steel. Stone Masonry - Brick Masonry – Types. Types and Uses of Beam, Column, Lintels, Flooring, Roofing. Foundation – Footings – Types. Basic Requirements of Building –					

Planning – Criteria. Surveying - Object of Surveying – Classification of Surveying – Instruments used for Chain surveying – Calculation of Areas. Leveling – Principle of leveling – Types – Plane Table Surveying.

UNIT 2: MANUFACTURING PROCESS AND IC ENGINES	**9**

Casting, Moulding, Patterns, Metal Working: Hot Working and Cold Working, Meta Forming: Extrusion, Forging, Rolling, Drawing, IC Engines: 2 - Stroke and 4 – Stroke Engines, S.I. Engine and C.I. Engine: Differences

UNIT 3: ELECTRICAL CIRCUITS	**9**

DC Circuits: Circuit Components: Conductor, Resistor, Inductor, Capacitor – Ohm's Law - Kirchhoff's Laws –Independent and Dependent Sources – Simple problems- Nodal Analysis, Mesh analysis with Independent sources only (Steady state) Introduction to AC Circuits and Parameters: Waveforms, Average value, RMS Value, Instantaneous power, real power, reactive power and apparent power, power factor – Steady state analysis of RLC circuits

UNIT 4: BASIC ELECTRONICS	**9**

Intrinsic semiconductors, Extrinsic semiconductors – P-type and N-type, P-N junction, VI Characteristics of PN junction diode, Zener effect, Zener diode, Zener diode Characteristics Rectifier circuits-Wave shaping circuit.

UNIT 5: BASIC COMPUTER APPLICATIONS	**9**

Generation of Computers – Applications of 5th generation computers – Basic concept of Networking – Server & Client - Network Topologies Internet, World Wide Web: Introduction to Internet, Internet Access, Internet Basics-World Wide Web (WWW), Web Pages. E-mail: Introduction to e-mail, Mailing basics.

TOTAL: 45 PERIODS

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

CO1: Explain the usage of construction material, proper selection of construction materials and also measure distances and area by surveying

CO2: Understand about Engineering Materials and IC Engines

CO3: Compute electric circuit parameter for simple problems

CO4: Understand the working principle of electronic devices such as diodes and zener diodes.

CO5: Understand the concepts of generation of computers and its applications

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2

CO1	1	2	1				2		2	2	1	2	-	-
CO2	2	2	1				2		2	2	2	2	-	-
CO3	2	3	2	3							1	1	-	-
CO4	2	3	3	3	3	1	-	1	1	-	1	3	-	-
CO5	1	1	1				1		1	1	1	3	-	-

1- Low, 2 - Medium, 3 - High, '-' No Correlation

TEXT BOOKS:

1. Shetty,M.S, "Concrete Technology", S.Chand and Company Ltd, New Delhi, 2015
2. Kothari DP and I.J Nagrath, "Basic Electrical and Electronics Engineering", McGraw Hill Education, 2014.
3. Sadhu Singh, Basic Mechanical Engineering, S. Chand Publishing, 2009.

REFERENCE BOOKS:

1. SeetharamanS., "Basic Civil Engineering", Anuradha Agencies, 2005.
2. Pravinkumar, Basic Mechanical Engineering, Pearson Education; Second edition, 2018.
3. R. K. Rajput, Basic Mechanical Engineering, Laxmi Publications; Fourth edition, 2007.
4. Thomas L. Floyd, 'Electronic Devices', 10th Edition, Pearson Education, 2018.
5. Albert Malvino, David Bates, 'Electronic Principles, McGraw Hill Education; 7th edition, 2017

WEB RESOURCES:

1. Fundamentals of Mechanical Engineering

https://www.youtube.com/watch?v=ehi_hkLlutw

2. IC Engines and Gas Turbines

https://archive.nptel.ac.in/courses/112/103/112103262/

IP620103 - PYTHON PROGRAMMING LABORATORY

Course Category: Institute Core	Course Type: Practical	L	T	P	C
		0	0	3	1.5

COURSE OBJECTIVES:

- To write, test, and debug simple Python programs
- To implement Python programs with conditionals and loops
- Use functions for structuring Python programs
- Represent compound data using Python lists, tuples, dictionaries
- Read and write data from/to files in Python

LIST OF EXPERIMENTS:

1. Compute the GCD of two numbers.
2. Find the square root of a number (Newton's method)
3. Exponentiation (power of a number)
4. Find the maximum of a list of numbers
5. Linear search and Binary search
6. Selection sort, Insertion sort
7. Merge sort
8. First n prime numbers
9. Multiply matrices
10. Programs that take command line arguments (word count)
11. Find the most frequent words in a text read from a file

TOTAL: 30 PERIODS

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

CO1: Write, test, and debug simple Python programs

CO2: Implement Python programs with conditionals and loops.

CO3: Develop Python programs step-wise by defining functions and calling them.

CO4: Use Python lists, tuples, dictionaries for representing compound data.

CO5: Solve problems using files in Python.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	1	-	-	-	-	-	-	-	-	2	-	-
CO2	-	-	-	-	2	-	-	-	-	-	1	2	-	-
CO3	-	-	-	-	-	2	-	-	-	-	2	2	-	-
CO4	2	3	3	-	-	-	-	-	-	-	2	2	-	-
CO5	2	2	2	-	-	-	-	-	-	-	2	2	-	-

1- Low, 2 - Medium, 3 - High, '-' No Correlation

IP620104 - ENGINEERING PRACTICE LABORATORY

Course Category: Institute Core	Course Type: Practical	L	T	P	C
		0	0	3	1.5

COURSE OBJECTIVES:

To provide hands on training in Sawing, planning, making joints in wood materials used in common household wood work, drawing pipe line plan; laying and connecting various pipe fittings used in common, household plumbing work, making a tray out of metal sheet using

sheet metal work, wiring various electrical joints in common household electrical wire work and Soldering and testing simple electronic circuits, house wiring system, measurement of electrical quantities, and handling electrical equipment.

LIST OF EXPERIMENTS:

CIVIL:

Carpentry& Plumbing:

1. Wood sizing exercise in planning, marking, sawing, chiseling and grooving to make; Tee Joint and Dovetail Joint.
2. Connecting various basic pipe fittings like valves, taps, coupling, unions, reducers, elbows and other components which are commonly used in household.
3. Laying pipe connection to the suction side of a pump
4. Laying pipe connection to the delivery side of a pump.
5. Connecting pipes of different materials: Metal, plastic and flexible pipes used in household appliances.

MECHANICAL:

Sheet Metal & Fasteners:

1. Fabrication of Dust Pan
2. Fabrication of Square tray.
3. Making bolted joints, screw joints and riveted joints.

ELECTRICALS:

1. Residential House wiring using switches, fuse, indicator, lamp and Energy meter
2. Different Types of wiring (Staircase and Fluorescent Lamp wiring)
3. Verification of Ohm's law
4. Measurement of Electrical quantities (Voltage, current, power and power factor in RLC series circuit)
5. Calculation of Magnetic flux in an electrical circuit.

ELECTRONICS:

1. Characteristics of PN junction diode
2. Characteristics of Zener diode
3. Half wave and full wave Rectifiers
4. Application of Zener diode as shunt regulator.
5. Characteristics of BJT and JFET

COMPUTER SCIENCE:

1. Setting IP address to the client system
2. Network cable crimping and Installation
3. Connecting two computers and verify data transmission
4. Folders and peripherals sharing
5. Creating mail ID

TOTAL: 45 PERIODS

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

CO1: Draw pipe line layout and connect various pipe fittings used in common household plumbing work

CO2: Make a tray out of metal sheet using sheet metal work and join the components using Screws, bolts and rivets.

CO3: Design House wiring system and measure the various electrical quantities in a circuit

CO4: Solder and test simple electronic circuits; Assemble and test simple electronic components on PCB.

CO5: Set IP address, connecting two computers and verify data transmission.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	1	-	-	1	1	-	3	-	-	-	-	-
CO2	3	3	1	-	-	1	1	-	3	-	-	-	-	-
CO3	2	2	2	3	1	-	-	-	1	2	2	1	-	-
CO4	2	1	3	1	-	-	-	-	2	1	2	2	-	-
CO5	3	1	2	2	-	-	-	-	1	2	1	1	-	-

1- Low, 2 - Medium, 3 - High, '-' No Correlation

INSTITUTE MANDATORY COURSE

IM620401 - ENVIRONMENTAL STUDIES					
Course Category: Institute Mandatory	**Course Type: Institute Mandatory**	**L**	**T**	**P**	**C**
		2	**0**	**0**	**0**
COURSE OBJECTIVES:					

The course deals with the fundamentals of environmental engineering and its application in pollution control. It is intended to impart the fundamental knowledge of environmental engineering along with the design aspect of some pollution control equipment. It will also help the young scientific professionals to keep their knowledge upgraded with the current thoughts and newer technology options along with their advances in the field of the

environmental/industrial pollution abatement.	
UNIT 1: INTRODUCTION	**4**
Man and environment, types of pollution, pollution controls aspects, Industrial pollution, pollution monitoring and analysis of pollutants, Indian pollution regulations Environmental quality and degradation, Industrial scenario in India.	
UNIT 2: INDUSTRIAL WASTEWATER TREATMENT	**6**
Sources and types of industrial wastewater – Nature and Origin of Pollutants - Industrial wastewater and environmental impacts. Regulatory requirements for treatment of industrial wastewater. Industrial Wastewater Treatment method-Membrane Technologies	
UNIT 3: SOLID WASTE MANAGEMENT	**6**
Type of waste collection systems, analysis of collection system –alternative techniques for collection system. Separation and Processing and Transformation of Solid Waste: unit operations user for separation and processing, Landfills: Site selection, design and operation, drainage and leachate collection systems –E waste - sources, collection, treatment and reuse management., Hazardous waste treatment technologies (Management & Handling) Rules,	
UNIT 4: AIR & NOISE POLLUTION	**8**
Air Pollution: Types of pollutants, their sources and impacts, air pollution meteorology, Equipment for control of pollution, air quality standards and limits. Noise Pollution: Types of noise, Impacts of noise, permissible limits of noise pollution, measurement of noise and control of noise pollution Effects on human being.	
UNIT 5: ENVIRONMENTAL LAWS& SUSTAINABLE DEVELOPMENT	**8**
Environmental regulations and policies; Environmental protection laws and acts; Corporate and international charters and protocols; Standards and Guidelines, Historical development of Environmental Impact Assessment; Towards Sustainable Future: Concept of Sustainable Development, Life cycle assessment; Environmental auditing; Eco-labelling of products; Environmental management systems particularly IS 14000 series. Concept of Green Computing.	
TOTAL: 45 PERIODS	
COURSE OUTCOMES: At the end of the course, the student will be able to	
CO1: Identify the sources and effects of pollutants to the environment	
CO2: Understand the various treatment technologies for industrial wastewater	
CO3: Understand the development and applications of various unit operation to control the toxic Elements.	

CO4: Identify the effect of the behaviour of air& noise pollutants on the environment.

CO5: Create awareness about environmental impact assessment (EIA) & Sustainable Development.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	2	-	-	2	2	-	-	-	-	2	-	-
CO2	3	2	2	2	-	2	2	-	-	-	-	2	-	-
CO3	3	2	2	2	-	2	3	-	-	-	-	2	-	-
CO4	3	2	2	1	-	2	2	-	-	-	-	2	-	-
CO5	3	1	2	-	-	2	2	2	2	2	2	2	-	-

1- Low, 2 - Medium, 3 - High, '-' No Correlation

TEXT BOOKS:

1. M.N. Rao, "Air Pollution", Tata McGraw Hill, 2018

2. Jeffrey Pierce J, "Environmental pollution and control", Butterworth-Heinemann,1998

3. Nicholas P. Cheremisinoff, Handbook of Air Pollution Prevention and Control. Butterworth-Heinemann, 2002

4. Noel de Nevers, Air Pollution Control Engg., McGraw-Hill, New York, 2012

5. N.K.Uberoi, Environmental Management, Excel Books, 2006

5. Singal, S.P., Noise Pollution and Control Strategy, Narosa Publishing House, 2005

REFERENCE BOOKS:

1. Westlake, K, Landfill Waste pollution and Control, Albion Publishing Ltd., England, 1995.

2. Garg, S.K., "Environmental Engineering Vol. I & II", Khanna Publishers, New Delhi, 2012

3. Modi, P.N., "Environmental Engineering Vol. I & II", Standard Book House, Delhi, 2013

4. Canter, W.L., Environmental Impact Assessment, McGraw-Hill Inc., 1992

5. Rau, J.G and Wooten, D.C., Environmental Impact Analysis Handbook, McGraw-Hill, 2015.

7. UNEP/IED Technical Report Serial No.2, Environmental Auditing, 1990.

8.. Metcalf & Eddy., Wastewater Engineering – Treatment and Reuse, Tata Mc. Graw-Hill Company, 2019

WEB RESOURCES:

1. Solid & Hazardous Waste Management

https://nptel.ac.in/courses/105/106/105106056/

2. Wastewater Treatment and Recycling.

https://nptel.ac.in/courses/105105178

3. The legal and regulatory framework for environmental protection in India. https://moef.gov.in/wp-content/uploads/wssd/doc2/ch2.html

4. Environment Management. https://nptel.ac.in/courses/120108004

SEMESTER 3

IC630017- NUMERICAL METHODS AND STATISTICS						
Course Category: Institute Core	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						
The objective of this course is to computing a value and being aware of two or more comparable values. When data series are organized as columns, interpolation occasionally aims to predict the future and should be representative in order for researchers to draw conclusions about the larger population and to approximate a bigger population on factors pertinent to the research subject.						
UNIT 1: SOLUTION OF EQUATION AND EIGNVALUE PROBLEM						**9**
Solution of linear system of equation – Bijection method – fixed point Iteration method – Newton Raphson Method – Ragula Falsi method – Decomposition Method – Gauss Elimination Method – Gauss Jordan Method – Gauss Jacobi Method –Finding largest eigen value- Inverse of matrix by Jordan Method.						
UNIT 2: INTERPOLATION AND APPROXIMATING POLYNOMIALS						**9**
Lagrangian polynomials – Divided difference formulae for equal intervals and unequal intervals – Interpolating with a cubic spline – Newton's forward and backward difference formulas – Stirlings formula.						
UNIT 3: NUMERICAL DIFFERENTIATION AND INTEGRATION						**9**
Differentiation using interpolation formulae – Numerical integration by trapezoidal and Simpson's 1/3 and 3/8 rule – Romberg's Method – Double integrals using trapezoidal and Simpson's rules.						
UNIT 4: THEORY OF ESTIMATION						**9**
Estimation: Point and Interval estimates for population parameters of large sample and small						

samples, determining the sample size.

UNIT 5: TESTING OF HYPOTHESIS	**9**

Sampling distributions – Testing of hypothesis for mean – variance –proportions and differences using Normal–'t'–Chi-square and F-distributions–Tests for independence of distributions of attributes and goodness of fit

TOTAL: 45 PERIODS

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

CO1: Compute the solutions of the variables using iterative methods.

CO2: Understand and apply methods to find interpolating and approximating polynomials.

CO3: Solve complicated differentiation and integration by numerical methods.

CO4: Identify the type of estimations for small samples and large samples

CO5: Solve the physical problems by small and large sampling theory

CO-PO MAPPING

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

1- Low, 2 - Medium, 3 - High, '-' No Correlation

TEXT BOOKS:

1. M.K. Jain, S.R.K. Iyengar and R.K. Jain "Numerical methods: for scientific and engineering computation" 2013. 6th ed.

2. Devore, J.L., "Probability and Statistics for Engineering and the Sciences", Cengage Learning, New Delhi, 8th Edition, 2014.

3. S.C. Gupta AND V.K. Kapoor "Fundamentals of mathematical statistics" Elevanth thoroughly revised ed., Sultan Chand & Sons educational publishers, New Delhi (June 2003)

4. T. Veerarajan, "Probability, Statistics and Random Processes" Tata McGraw-Hill Publishing Company Limited, New Delhi (2006)

REFERENCE BOOKS:

1. Sankararao.K, "Numerical Methods for Scientists and Engineers" -3rd edition Printice Hall of India Private Ltd. New Delhi-(2007).

2. Walpole, R.E., Myers, R.H., Myers, S.L. and Ye. K., "Probability and Statistics for Engineers and Scientists", 9th Edition, Pearson Education, Asia, 2010

3. Veerarajan.T and Ramachandran. T, "Numerical Methods with Programming in C"

second Ed., Tata Mc. Graw Hill Publishing. Co. Ltd (2007)

EE630201- ANALOG ELECTRONICS CIRCUITS					
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To impart an in depth knowledge in electronic semiconductor devices & circuits giving importance to the various aspects of design & analysis.
- To provide knowledge about different types amplifier & oscillator circuits and their design.
- To provide a thorough understanding of the operational amplifier circuits and their functions.

UNIT 1: BIPOLAR JUNCTION TRANSISTORS **9**

Review of BJT, characteristics- Operating point of a BJT – Factors affecting stability of Q point and DC Biasing – Biasing circuits: fixed bias, collector to base bias, voltage division bias and self bias. (Derivation of stability factors for Voltage Divider Biasing only) –Bias compensation using diode and thermistor.

UNIT 2: FIELD EFFECT TRANSISTORS **9**

Review of JFET and MOSFET construction, working and characteristics- Biasing a JFET and MOSFET using voltage divider bias- CS and CD amplifiers – small signal models-FET as switch and voltage controlled resistance

UNIT 3: MULTISTAGE AMPLIFIERS **9**

Direct, RC, transformer coupled amplifiers – Power amplifiers using BJT: Class A, Class B and Class AB and class C- Conversion efficiency and distortion in power amplifiers. Feedback Amplifiers- Effect of positive and negative feedbacks- Basic feedback topologies and their properties

UNIT 4: OSCILLATORS **9**

Bark Hausen's criterion – RC oscillators (RC Phase shift oscillator and Wein Bridge oscillator) –LC oscillators (Hartley and Colpitt's) - Derivation of frequency of oscillation for the above mentioned oscillators- Crystal oscillator.

UNIT 5: OP-AMP CIRCUITS **9**

Review of inverting and non-inverting amplifier circuits- Summing and difference amplifiers, Differentiator and Integrator circuits Logarithmic amplifier- Half Wave Precision

rectifier - Instrumentation amplifier

TOTAL: 45 PERIODS

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

CO1: Design biasing scheme for transistor circuits

CO2: Model BJT and FET amplifier circuits

CO3: Choose a power amplifier with appropriate specifications for electronic circuit applications

CO4: Design & analyse oscillator circuits using BJT

CO5: Choose Operational amplifier (OPAMP) for specific applications including waveform generation.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	2	-	-	2	2	-	-	-	-	2	-	3
CO2	3	2	3	2	-	3	2	-	-	-	-	2	2	-
CO3	3	2	3	2	1	2	3	-	-	-	-	2	2	3
CO4	3	2	2	1	-	2	2	-	-	-	-	2	2	-
CO5	3	1	2	-	-	2	2	2	2	2	2	2	-	3

1- Low, 2 - Medium, 3 - High, '-' No Correlation

TEXT BOOKS:

1. Malvino A. and D. J. Bates, Electronic Principles 7/e, Tata McGraw Hill, 2010.

2. Boylestad R. L. and L. Nashelsky, Electronic Devices and Circuit Theory, 10/e, Pearson Education India, 2009.

3. Choudhury R., Linear Integrated Circuits, New Age International Publishers. 2008.

REFERENCE BOOKS:

1. Floyd T. L., Fundamentals of Analog Circuits, Pearson Education, 2012.

2. Robert T. Paynter and John Clemons, Paynter's Introductory electronic devices & circuits, Prentice Hall Career & Technology, New Jersey.

3. Bell D. A., Electronic Devices and Circuits, Prentice Hall of India, 2007.

4. Millman J. and C. C. Halkias, Integrated Electronics: Analog and Digital Circuits and Systems, Tata McGraw-Hill, 2010.

5. Streetman B. G. and S. Banerjee, Solid State Electronic Devices, Pearson Education Asia, 2006.

6. Gayakward R. A., Op-Amps and Linear Integrated Circuits, PHI Learning Pvt. Ltd., 2012.

WEB RESOURCES:

1. Working Principle of Operational Amplifier. https://www.electrical4u.com/op-amp-

working-principle-of-op-amp/ 2. Bipolar Junction Transistor. https://www.tutorialspoint.com/bipolar-junction-transistor-bjt-theory

EE630202- MEASUREMENTS AND INSTRUMENTATION						
Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						
To impart knowledge on • The instrument types and their operation. • The various electrical measuring meters construction and their working principles. • The working of instrument transformers. • Measurement of Magnetic parameters, and Electronics Instruments.						
UNIT 1: INTRODUCTION						**9**
Definitions- Accuracy, Precision, resolution, tolerance, sensitivity, reproducibility, Types of instruments- Indicating, recording, integrating.						
UNIT 2: ELECTRICAL MEASURING INSTRUMENTS						**9**
Analog Ammeters and Voltmeters: Permanent magnet Moving Coil (PMMC) & Moving Iron (MI) instruments: construction, torque equation range extension, effect of temperature, classification, errors, advantages and disadvantages. Analog Wattmeter and Power Factor Meters: Electrodynamometer type: wattmeter and power factor meter: construction, working, torque equation, advantages and disadvantages; Measurement of active and reactive power in single phase and in three phase with balanced loads.						
UNIT 3: INSTRUMENT TRANSFORMERS						**9**
Construction, working, phasor diagram, ratio error and phase errors, testing & applications of current transformer and potential transformer.						
UNIT 4: DC AND AC BRIDGES						**9**
DC bridges: Wheatstone, Kelvin's, Kelvin's double bridge, Megger, Earth resistance measurement, loss of charge method for measurement of high resistance; AC bridges: Maxwell's bridges, De-Sauty, Anderson, Schering, Wien; for measurement of inductance and capacitance and their limitations.						
UNIT 5: TRANSDUCERS AND ELECTRONIC INSTRUMENTS						**9**

Thermistor, RTD, thermocouple, LVDT, strain gauge, piezoelectric transducers, digital shaft encoders, tachometer, Hall Effect sensors.

Digital voltmeters, Smart Energy Meter- Automatic Meter Reading (AMR), Advanced Metering Infrastructure (AMI) environments.

TOTAL: 45 PERIODS

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

CO1: Differentiate various types of instruments and their operating principle.

CO2: Understand the operating principles of electrical measurement devices.

CO3: Explain the operation of instrument transformers.

CO4: Realize the operation of different types of bridge circuits and their uses.

CO5: Explain the operation of different types of transducers and various digital measurement meters.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	1	1	-	-	-	-	2	1	1	2	3	-
CO2	3	2	1	1	-	-	-	-	2	1	1	2	3	-
CO3	3	2	1	1	-	-	-	-	2	1	1	2	3	-
CO4	3	1	1	1	-	-	-	-	2	1	2	2	3	-
CO5	3	1	1	1	-	-	-	-	2	1	2	2	3	-

1- Low, 2 - Medium, 3 - High, '-' No Correlation

TEXT BOOKS:

1. A.K. Sawhney, 'A Course in Electrical & Electronic Measurements & Instrumentation', DhanpatRai and Co, 20th edition, Reprint 2015.

2. H.S. Kalsi, 'Electronic Instrumentation', Tata McGraw Hill, 3rd Edition, Reprint 2012.

3. J. B. Gupta, 'A Course in Electronic and Electrical Measurements', S. K. Kataria & Sons, Delhi, Reprint 2013.

REFERENCE BOOKS:

1. A.J. Bkouwens, 'Digital Instrumentation', Tata McGraw Hill, 2010.

2. D.V.S. Moorthy, 'Transducers and Instrumentation', Prentice Hall of India Pvt Ltd, 2011.

3. Golding E.W and Widdis, "Electrical Measurements & Measuring Instruments", Reem Publication, 2011.

Introduction to Measurements and Instrumentation, Arun K. Ghosh, Fourth Edition, Eastern Economy Edition, PHI Learning, 2012.

4. Dr. Shashikant Bakre, Electricity Metering in Easy Steps: An outline book on smart energy meters for everyone, 2015.

WEB RESOURCES:

1. Electrical Measurement and Electronic Instruments.

https://nptel.ac.in/courses/108/105/108105153/

2. SMART ENERGY.

https://www.cdac.in/index.aspx?id=pe_pe_PEG_SMARTENERGY

EE630203- ELECTROMAGNETIC FIELDS					
Course Category: Program Core	**Course Type: Theory with project**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To study the basic concepts of vector analysis and the concept of electrostatics, electrical potential and energy density.
- To study the concept of magneto statics, magnetic flux density and Electric and Magnetic fields in materials.
- To study the concept of electro dynamic fields and electromagnetic waves.

UNIT 1: VECTOR ANALYSIS **9**

Vector fields – Different Co-ordinate systems - Rectangular, Cylindrical and Spherical coordinate systems. Gradient - Divergence – Curl - Line Integral-Surface Integral-Divergence theorem- Stoke's theorem

UNIT 2: ELECTROSTATICS **9**

Coulomb's Law in Vector Form – Definition of Electric Field Intensity – Electric Field due to discrete charges – Electric field due to continuous charge distribution - Electric Field due to charges distributed uniformly on an infinite line – Electric Field on the axis of a uniformly charged circular disc-Electric Scalar Potential – Relationship between potential and electric field - Potential due to infinite uniformly charged line – Potential due to electrical dipole - Electric Flux Density – Gauss Law – Proof of Gauss Law.

UNIT 3: MAGNETOSTATICS **9**

Theories of magnetic field- Biot-Savart Law in vector form – Magnetic Field intensity due to a finite and infinite wire carrying a current I – Magnetic field intensity on the axis of a circular loop– Ampere's circuital law. Magnetic flux density – Lorentz Law of force – Force on a wire carrying a current I placed in a magnetic field – Torque on a loop carrying a current I – Magnetic moment – Magnetic Vector Potential.

UNIT 4: ELECTRIC AND MAGNETIC FIELDS IN MATERIALS **9**

Poisson's and Laplace's equation – Electric field in free space, conductors, dielectric - Dielectric polarization – Capacitance- Dielectric strength - Electric field in multiple

dielectrics – Electrostatic energy and energy density – Boundary conditions for electric fields. Self and mutual Inductance of loops and solenoids -Energy density in magnetic fields – magnetic boundary conditions

UNIT 5: ELECTRODYNAMIC FIELDS AND ELECTROMAGNETIC WAVES | **9**

Displacement current - Maxwell's equations (differential and integral forms) –.Electro Magnetic wave equations – Uniform plane waves - Wave parameters- velocity, intrinsic impedance, propagation constant – Waves in free space, lossy and lossless dielectrics, conductors-skin depth, Poynting Theorem, energy in electro-magnetic fields.

TOTAL: 45 PERIODS

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

CO1: Do problems in the fundamentals of vector fields.

CO2: Solve the problems in the concept of electro static fields.

CO3: Solve the parameters using laws of magnetic field.

CO4: Estimate the values of electric and magnetic fields parameters in materials.

CO5: Solve Maxwell's equations and problems in electromagnetic waves equations.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	-	-	-	-	2	1	1	2	3	-
CO2	3	2	1	1	-	-	-	-	2	1	1	2	3	-
CO3	3	2	1	1	-	-	-	-	2	1	1	2	3	-
CO4	3	1	1	1	-	-	-	-	2	1	2	2	3	-
CO5	3	1	1	1	-	-	-	-	2	1	2	2	3	-

TEXT BOOKS:

1.Engineering Electromagnetics, William H. Hayt Jr., John A. Buck, and M Jaleel Akhtar, McGraw Hill, 9th Edition, 2020.

2. Introduction to Electrodynamics, David J.Griffiths, Pearson Education, 2013, 4th Edition, 2013.

3. Analysis of Electric Machinery & Drive systems, Paul C. Krause, Oleg Wasynczuk, Scott D.Sudhoff, and Steven D. Pekarek, Wiley-IEEE Press, 3rd Edition, 2013.

REFERENCE BOOKS:

1.Elements of Electromagnetics, Matthew Sadiku and S.V. Kulkarni, Oxford University Press, 6th Edition, 2015.

2. Engineering Electromagnetics, Nathan Ida, Springer, 4th Edition, 2021.

3. Electrical Machines, A.E Fitzgerald, C. Kingsely and S. Umans, McGraw Hill, 6th Edition, 2017.

WEB RESOURCES:

1. Introduction To Vector. https://nptel.ac.in/courses/108/106/108106073/

2. L1-Scalar field and its Gradient. https://nptel.ac.in/courses/115/101/115101005/

EE630204- ELECTRIC CIRCUITS AND NETWORKS (PRACTICAL COMPONENT)		
Course Category: Program Core	**Course Type: Theory with Practical Component**	**L T P C** **2 0 2 3**
COURSE OBJECTIVES:		

- To stimulate the students for solving AC and DC circuits using various laws and theorems.
- To motivate the students for solving transient and steady state problems.
- To make the students understand the concepts and terminologies of series & parallel resonance circuits and coupled circuits among the students.
- To inspire the students for analyzing three phase 3 wire and 4 wire circuits and network Parameters.

UNIT 1: BASICS OF CIRCUIT ANALYSIS	**9**

Classification of Circuit Elements – Ohm's law - Kirchoff's laws – Reistance, Inductance and Capacitance in series and parallel combination- Source transformation - Star - Delta transformation.- Mesh and Nodal analysis (DC and AC circuits) - Graph of a network, Incidence matrix, Dual networks.

UNIT 2: NETWORK THEOREMS	**9**

Superposition theorem - Thevenin's Theorem - Norton's Theorem - Maximum power transfer theorem - Reciprocity theorem, Millman's theorem, Tellegen's theorem.

UNIT 3: TRANSIENT AND STEADY STATE ANALYSIS	**9**

Transient Analysis: Transients in RC, RL and RLC circuit with DC Excitation.
Steady state Analysis: Voltage, Current relationship of RL series - RC series - RLC series and Parallel circuits – powers, power factor and phasor diagram.

UNIT 4: RESONANCE AND COUPLED CIRCUITS	**9**

Series resonance - Parallel resonance – Resonant frequency - Bandwidth -Q factor – Selectivity - MMF, flux and magnetic reluctance, Self and mutual inductances, Dot convention, coefficient of coupling and coupled circuits.

UNIT 5: THREE PHASE CIRCUITS	**9**

Phase sequence – Balanced star and Delta connected load – Unbalanced star and Delta connected load – power measurement in 3 phase circuits-Neutral voltage calculations, complex power.

PRACTICAL COMPONENT **15**

- Verification of KCL and KVL
- Verification of Superposition Theorem
- Verification of Thevenin's, Norton's and Maximum Power Transfer Theorems
- Study of CRO and measurement of sinusoidal voltage, frequency and power factor
- Frequency Response of Parallel Resonance circuit
- Frequency Response of Series Resonance circuit
- Design and simulation of series and parallel resonance circuit using MatLab / ORCAD PSPICE.
- Determination of time constant of RL and RC series circuit
- Frequency Response of single tuned Coupled circuit
- Power measurement using two wattmeter method.

TOTAL: 60 PERIODS

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

CO1: Understand the basic laws, mesh current, nodal voltage, voltage and current division, source transformation and star/delta transformation methods for solving circuit problems and to identify the dual for a given electric circuit.

CO2: Solve networks using the network theorems for DC and AC inputs.

CO3: Formulate the dynamic response, evaluate initial conditions and assess the time - domain response of RLC circuits and analyse the concepts of steady state parameters of the same circuits.

CO4: Analyse magnetic circuits, evaluate steady-state response and determine resonance characteristics of AC electric circuits.

CO5: Analyse the three phase balanced and unbalanced three phase circuits with star and delta connected loads.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	-	-	-	-	2	2	1	2	1	-
CO2	3	3	3	3	-	-	-	-	2	2	1	2	-	1
CO3	3	3	3	3	2	-	-	-	2	2	1	2	2	1
CO4	3	3	3	3	-	-	-	-	2	2	1	2	1	1
CO5	3	3	3	3	-	-	-	-	2	2	1	2	1	2

TEXT BOOKS:

1. Nageswararao. T, Electric Circuit Analysis, 10th edition, A.R.Publications, Chennai 2010
2. Sudhakar, A. and Shyam Mohan.S.P, Circuits and Networks Analysis and Synthesis, 5th edition, Tata McGraw Hill Publishing Co. Ltd. New Delhi 2015.

REFERENCE BOOKS:

1. Arumugam and Premkumar, Electric Circuit Theory, Khanna Publishers.2012.

2. Abhijit Chakrabarti., Circuit Theory Analysis and Synthesis, 7th Revised Edition paper back 2018.

3. M Nahvi, Joseph Edminister and K Uma Rao, Electric circuits, Schaum's outline series, 5th edition, 2010

4. Engineering Circuit Analysis, William H. Hayt Jr., Jack E. Kemmerly, Steven M. Durbin, Tata McGraw Hill, 2013, 8th Edition.

WEB RESOURCES:

1. Introduction To Vector. https://nptel.ac.in/courses/108/106/108106073/

2. L1-Scalar field and its Gradient. https://nptel.ac.in/courses/115/101/115101005/

EE630301- ANALOG ELECTRONIC CIRCUITS LABORATORY

Course Category: Program Core	Course Type: Practical	L	T	P	C
		0	0	3	1.5

COURSE OBJECTIVES:

LIST OF EXPERIMENTS:

1. Measurement of current, voltage, frequency and phase shift of signal in a RC network using oscilloscope.
2. Clipping circuits using diodes.
3. Clamping circuits using diodes.
4. Design and testing of simple Zener voltage regulator.
5. RC coupled amplifier using BJT in CE configuration-Measurement of gain, BW and plotting of frequency response.
6. JFET amplifier-Measurement of gain, BW and plotting of frequency response.
7. Op-amp circuits – Design and set up of inverting and non-inverting amplifier, scale changer, adder, integrator, and differentiator.
8. Op-amps circuits – Scale changer, adder, integrator, and differentiator.
9. Precision rectifier using Op-amps.
10. Phase shift oscillator using Op-amps.
11. Wein's Bridge oscillator using Op-amps.

12. Waveform generation– Square, triangular and saw tooth waveform generation using OPAMPs.

TOTAL: 45 PERIODS

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

CO1: Use the various electronic instruments and for conducting experiments.

CO2: Design and develop various electronic circuits using diodes and Zener diodes.

CO3: Design and implement amplifier and oscillator circuits using BJT and JFET.

CO4: Design and implement basic circuits using ICs

CO5: Design and generate waveforms using OPAMPs

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	-	-	-	1	-	3	-	-	-	-	3
CO2	3	3	2	-	-	-	1	-	3	-	-	-	2	2
CO3	3	2	2	3	1	-	-	-	1	2	2	1	2	2
CO4	3	1	3	1	-	-	-	-	2	1	2	2	3	3
CO5	3	2	2	2	-	-	-	-	1	2	1	1	-	-

1- Low, 2 - Medium, 3 - High, '-' No Correlation

EE630302- MEASUREMENTS AND INSTRUMENTATION LABORATORY

Course Category: Program Core	Course Type: Practical	L	T	P	C
		0	0	3	1.5

COURSE OBJECTIVES:

- To offer strong background in different types of sensors and measuring devices.
- To provide mathematical foundation and there by the relative analysis of measuring calculations.
- To provide knowledge on various lab experiments connected with sensors and measuring instrument and there by achieve the design concepts.

LIST OF EXPERIMENTS:

1. Study and observe the oscilloscope as a test and measuring instrument.

(Test the resistors, capacitors, diodes, transistors, measure AC/DC voltages, frequency, phase and study the Lissajous patterns).

2. Plot the B-H curve of a magnetic specimen to obtain its hysteresis loss and calculate its Steinmetz's constant & co-efficient.

3. Calibrate the single phase energy meter by phantom loading for various loads and power factors.

4. Measurement of low resistance using Kelvin double bridge.

5. Measurement of inductance and capacitance using Maxwell bridges.

6. Measurement of inductance using Anderson bridge.

7. Measurement of capacitance using Schering bridge.

8. Measurement of ratio error and phase error of a potential transformer

9. Measurement of ratio error and phase error of a current transformer.

10. Measurement of temperature using RTD and thermistor

11. Measurement of pressure and weight using piezoelectric transducer.

12. Measurement of power factor using two-watt meter method.

13. Measurement of reactive power in a balanced three phase system using single wattmeter method.

14. Measurement of active power in a balanced three phase system using two wattmeter method.

TOTAL: 45 PERIODS

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

CO1: Justify the operating principle and characteristics of various sensors.

CO2: Apply the procedure to measure the electrical quantities using measuring instruments.

CO3: Determine the electrical parameters using different types of Bridges

CO4: Demonstrate the function of Transducers and wattmeter.

CO5: Perform the calibration test for various meters.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	-	-	1	-	3	3	3	2	1	1
CO2	3	2	1	-	1	-	1	-	3	3	3	2	1	1
CO3	3	1	1	1	1	-	-	-	3	3	3	2	1	1
CO4	3	2	1	1	1	-	-	-	3	3	3	2	1	1
CO5	3	3	2	2	-	-	1	-	3	3	3	2	2	2

1- Low, 2 - Medium, 3 - High, '-' No Correlation

SEMESTER 4

IC640018- BOUNDARY VALUE PROBLEMS AND PROBABILITY DISTRIBUTION					
Course Category: Institute Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:		
Objective of the subject is to provide a venue for the promotion, encouragement, and interdisciplinary collaboration of various fields using the theory, techniques, and applications of boundary value problems and Make predictions about the likelihood of specific events using the probability distribution for discrete random variables (general, binomial,). Students will use the normal distribution's fundamentals to calculate probability. Implement a normal distribution. Check out a normal distribution.		
UNIT 1: INITIAL VALUE PROBLEMS FOR ORDINARY DIFFERENTIAL EQUATIONS		**9**
Single Step Methods: Taylor Series Method – Euler Method for First Order Equation – Fourth Order Runge – Kutta Method for Solving First and Second Order Equations – Multistep Methods: Milne's and Adam's Predictor and Corrector Methods		
UNIT 2: BOUNDARY VALUE PROBLEMS IN ORDINARY AND PARTIAL DIFFERENTIAL EQUATIONS		**9**
Finite Difference Solution of Second Order Ordinary Differential Equation – Finite Difference Solution of One Dimensional Heat Equation by Explicit and Implicit Methods – One Dimensional Wave Equation and Two Dimensional Laplace and Poisson Equations		
UNIT 3: PROBABILITY AND RANDOM VARIABLES		**9**
Random experiment – sample space – concept of probability Axioms of Probability – conditional probability –Total probability - Baye's theorem - Discrete and continuous type of random variables - Moments - Moment generating functions and their properties		
UNIT 4: STANDARD DISTRIBUTIONS		**9**
Discrete distributions: Binomial, Poisson, Geometric, Negative Binomial – Continuous distributions - Uniform, Normal, Exponential, Gamma, and Weibull distributions – Mean and variance of distribution – Method of finding Mean and variance using MGF		
UNIT 5: TWO DIMENSIONAL RANDOM VARIABLES		**9**
Joint distributions - Marginal and conditional distributions -Independent random variables - Covariance - Correlation and Regression - Transformation of random variables - Central limit theorem with its applications.		
TOTAL: 45 PERIODS		
COURSE OUTCOMES: At the end of the course, the student will be able to		
CO1: Apply the method of finding numerical solution for differential equation by initial value problems and terminal problem		

CO2: Apply the method of finding numerical solution for differential equation by boundary value problems and with their application.
CO3: Gain knowledge about conditional probability and applications of Baye's theorem
CO4: Identify the different types of distribution and apply in real life
CO5: Apply the discrete data to analyse the correlation and regression

CO-PO MAPPING

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

TEXT BOOKS:

1. Richard A. Johnson Irwin Miller and John E. Freund, ``Probability and Statistics for Engineers", Prentice Hall, New Delhi, 11th Edition, 2011.
2. Oliver C. Ibe, ``Fundamentals of applied probability and random processes", Academic press, 2005.

REFERENCE BOOKS:

1. Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers and Keying E. Ye, ``Probability and statistics for engineers and scientists'', 9th Edition, Pearson, 2011.
2. Jay L. Devore, ``Probability and statistics for engineering and the sciences", Cengage Learning, 8th Edition, 2011

EE640205- ELECTRICAL CONTROL SYSTEMS

Course Category: Program Core	**Course Type: Theory with Practical Component**	**L**	**T**	**P**	**C**
		2	**0**	**2**	**3**

COURSE OBJECTIVES:

- To understand the basic components of control systems and transfer function modelling of electrical systems.
- To gain knowledge in various time domain and frequency domain tools for analysis and design of linear control systems.
- To learn Frequency domain analysis using various graphical methods.
- To do Stability analysis of control system.
- To design the types of compensators.

UNIT 1: SYSTEMS AND THEIR REPRESENTATION	9
System, control system, types of control systems, Transfer Function, open loop and closed loop systems, types of feedback, feedback and its effects. Mathematical modelling of Electrical and Electromechanical elements, D.C. motors - Block diagram illustration. Introduction, Block diagram reduction technique and signal flow graph, Mason's gain formula.	
UNIT 2: TIME RESPONSE ANALYSIS	**9**
Mathematical expression for standard test signals – Type and order of systems – Time response of first order and second order systems - Time domain specifications – Steady state error analysis - Generalized error series – Transfer function model and characteristics of P, PI, PD and PID controllers. Introduction to PID controller- PID Controller tuning using Ziegler Nichols's method.	
UNIT 3: FREQUENCY DOMAIN ANALYSIS	**9**
Frequency response analysis – frequency domain specifications of second order systems – Correlation between time domain and frequency domain specifications– polar plots, bode plots – Determination of Gain margin and phase margin.	
UNIT 4: STABILITY ANALYSIS AND DESIGN OF COMPENSATORS	**9**
Characteristics equation –Concepts of Stability - Location of roots in S-plane for stability- Routh-Hurwitz Stability criterion – Necessary and sufficient conditions for stability– Root locus concept-Rules for construction of root loci- Root locus plot for stability analysis. Need for Compensation – Compensation Techniques - Design of Lag, Lead and Lag Lead Compensator using bode plot.	
UNIT 5: STATE SPACE ANALYSIS	**9**
Introduction to multiple input multiple output systems - - Concepts of State, State variable, State model-State models for simple electrical system– Phase variable model – Canonical model. Controllability and Observability using Kalman's test method.	
PRACTICAL COMPONENT	**15**
• Introduction to simulation software like MATLAB/LABVIEW • Modelling of DC Motor using simulation software • Digital simulation of first and second order systems for different inputs • Given a system transfer function, plot the location of the system zeros and poles using simulation software	

- Stability analysis by root locus plot using MATLAB program.
- Stability analysis of linear systems using Bode plot.
- Design of PID controller using Ziegler Nichol's method
- Speed control of DC Motor using PID Controller

TOTAL: 60 PERIODS

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

CO1: Develop mathematical models of electrical and mechanical systems

CO2: Estimate the time domain and frequency domain specifications

CO3: Analyze the performance and stability of system through time domain and frequency domain approach.

CO4: Design the lag and lead compensators for desired system performance

CO5: Frame various types of state space model of a system.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	1	2	-	-	2	1	2	3	1	1
CO2	3	3	3	3	1	1	-	-	2	1	2	2	1	1
CO3	3	3	3	3	2	1	-	-	2	1	2	3	1	1
CO4	3	3	3	3	3	3	-	-	2	1	2	3	1	1
CO5	3	3	3	3	3	1	-	-	2	1	2	3	2	2

TEXT BOOKS:

1. J. Nagrath & M. Gopal, "Control Systems Engineering", New Age International Publishers, 5th edition, Multicolour edition, 2018.
2. M. Gopal, "Control Systems, Principles & Design", Tata McGraw Hill, 5th edition New Delhi, 2012.

REFERENCE BOOKS:

1. B.C. Kuo, "Automatic Control Systems", Prentice Hall of India Ltd., 9th edition New Delhi, 2009.

2. M.N. Bandyopadhyay, "Control Engineering Theory and Practice", Prentice Hall of India, 2004.

3. S. Salivahanan, R. Rengaraj& G. R. Venkatakrishnan, "Control Systems Engineering", Pearson publications., Chennai, 2015

4. Katsuhiko Ogata, Modern Control Engineering, Pearson Education India, 5th Edition, 2015.

WEB RESOURCES:

1. Control Engineering. https://www.controleng.com

2. Introduction to control problem. https://nptel.ac.in/courses/108/102/108102043/

EE640206 - DC MACHINES AND TRANSFORMERS						
Course Category: Program Core	**Course Type: Theory with project**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						
To make the students to understand the concepts of electro mechanical energy conversion and its interpretation in DC Machines and Transformers.						
UNIT 1: ELECTROMECHANICAL ENERGY CONVERSION PRINCIPLES						**9**
Principle of Energy conversion – Review of magnetic circuit–Faraday's law of induced EMF - Hysteresis and Eddy Current losses – AC operation of magnetic circuits - Singly and Doubly Excited magnetic field systems – Torque production in rotating machines.						
UNIT 2: DC MACHINES						**9**
Constructional features of a DC machine – Principle of Operation of DC generator – EMF equation – Methods of Excitation – Types of generator – No load and Load characteristics of DC generators – Commutation – Armature Reaction and its effects – Parallel operation of DC shunt generators – Problems on EMF equation, and armature reaction, Applications. DC MOTOR-Principle of operation – Back EMF & Torque equation – Characteristics of series, shunt & compound motors.						
UNIT 3: SPEED CONTROL AND TESTING OF DC MOTORS						**9**
Speed Control of DC Motors: Speed control of shunt & series motors, losses in DC machines and calculation of efficiency. Need for starters, types of starters and Starters for DC series, shunt and compound motors. Testing of DC Motors: No-load test, load tests and regenerative tests such as Swinburne's Test, Direct load test, Hopkinson's test, Field's test and Retardation test. Calculation of efficiency based on all the above tests.						
UNIT 4: TRANSFORMERS						**9**
Construction – Principle of Operation – EMF Equation –Transformer on no load and load – Phasor diagram –Equivalent Circuit –Auto Transformer –Tap Changing – Parallel operation of single phase transformers – Three phase transformer Connections – Scott Connection – Parallel operation of three phase transformers.						
UNIT 5: TESTING OF TRANSFORMER						**9**
Testing of Transformer: Polarity test, Open Circuit and short circuit tests & Sumpner's test						

– Losses, Efficiency and Voltage Regulation.

TOTAL: 45 PERIODS

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

CO1: Elaborate the operation of Electro mechanical Energy Conversion

CO2: Analyse the concept of operation of the DC machines and their relevant problems.

CO3: Classify the concepts of testing and speed control of DC motors.

CO4: Explain the operation of single phase transformer and three phase transformers.

CO5: Illustrate the testing of transformer in detail.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	-	-	-	-	2	2	2	3	1	2
CO2	3	2	1	1	-	--	-	-	2	2	2	3	1	2
CO3	3	2	1	1	-	-	-	-	2	2	2	3	1	2
CO4	3	2	1	1	-	-	-	-	2	2	2	3	1	2
CO5	3	2	1	1	-	-	-	-	2	2	2	3	2	2

TEXT BOOKS:

1. Theraja, B.L., "A Text book of Electrical Technology", Vol. II, S.C Chand and Co., New Delhi, Reprint 2014.
2 Nagarath & D.P.Kothari: Electrical Machines, TMH Publishers, 5th edition 2017.
3.Electrical Machinery, Theory: Performance & Applications, Dr. P. S. Bimbhra, Khanna Publishers, 2021.
4.Fitzgerald and Kingsley's electric machinery by Stephen D. Umans–TMH Publishers, 7th Edition, 2020.

REFERENCE BOOKS:

1. Theory& Performance of Electrical Machines by J.B. Gupta, S.K. Kataria & Sons, 5th Edition, 2013.

2. P. C. Sen., 'Principles of Electrical Machines and Power Electronics', John Wiley&Sons, 2007

3. The Performance and Design of Direct Current Machines, A.E .Clayton & NN Hancock, CBS Publishers, 2004.

WEB RESOURCES:

Electrical Machines -I

1. https://nptel.ac.in/courses/108/105/108105155/

2. https://nptel.ac.in/courses/108/105/108105017/

3. https://nptel.ac.in/courses/108/106/108106071/

EE640207- LINEAR INTEGRATED AND DIGITAL LOGIC CIRCUITS

Course Category: Program Core	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To get knowledge on Op-amp characteristics and Applications of Op-amp.

To study various number systems and to know about the combinational and various sequential circuits.

UNIT 1: IC FABRICATION **9**

IC classification, fundamental of monolithic IC technology, epitaxial growth, masking and etching, diffusion of impurities, Active and passive components of ICs, Fabrication of a typical circuit. Realization of monolithic ICs and packaging. Fabrication of diodes, capacitance, resistance and FETs, Thin and Thick film technology, State of the art Technology trends in IC fabrication.

UNIT 2: CHARACTERISTICS AND APPLICATIONS OF OPAMP **9**

Ideal OP-AMP characteristics, DC characteristics, AC characteristics, differential amplifier; frequency response of OP-AMP, DC and AC performance characteristics, slew rate.

Basic applications of op-amp – Inverting and Non-inverting Amplifiers, summer, differentiator and integrator-V/I & I/V converters.

Instrumentation amplifier, Log and Antilog Amplifiers, first and second order active filters, comparators, multivibrators, waveform generators, clippers, clampers, peak detector, S/H circuit, D/A converter (R- 2R ladder and weighted resistor types), A/D converters using op amps.

UNIT 3: SPECIAL AND APPLICATION ICs **9**

Functional block, characteristics of 555 Timer and its PWM application - IC-566 voltage controlled oscillator IC; 565-phase locked loop IC.

IC voltage regulators -723 regulator, switching regulator, MA 7840, LM 380 power amplifier, ICL8038 function generator, Frequency to Voltage and Voltage to Frequency converters, isolation amplifiers, opto coupler, opto electronic ICs, Industrial Applications

UNIT 4: NUMBER SYSTEMS AND COMBINATIONAL CIRCUITS **9**

Review of number systems, binary codes, error detection and correction codes (Parity and Hamming code) - Combinational logic - representation of logic functions-SOP and POS forms, K-map representations - minimization using K maps - simplification and implementation of combinational logic – multiplexers and de multiplexers - code converters, adders, subtractors, Encoders and Decoders

UNIT 5: SYNCHRONOUS SEQUENTIAL CIRCUITS & ASYNCHRONOUS SEQUENTIAL CIRCUITS	9

Sequential logic- SR, JK, D and T flip flops - level triggering and edge triggering - counters - asynchronous and synchronous type - Modulo counters - Shift registers - design of synchronous sequential circuits – Moore and Melay models- Counters, state diagram; state reduction; state assignment. Asynchronous sequential logic circuits-Transition Stability, flow stability-race conditions, hazards &errors in digital circuits; analysis of asynchronous sequential logic circuits.

TOTAL: 45 PERIODS

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

CO1: Explain the fabrication methods of op-amp.

CO2: Explain the characteristics of op-amp and different applications using general purpose op- amp.

CO3: Design special and application specific ICs

CO4: Understand the concepts of number system and design various combinational circuits.

CO5: Design synchronous sequential circuits and asynchronous sequential circuits.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	-	-	-	-	-	-	-	2	3	1
CO2	2	2	2	-	-	-	-	-	-	-	-	1	3	1
CO3	3	2	3	2	2	2	-	-	1	-	-	2	3	1
CO4	2	3	2	2	-	-	-	-	-	-	2	2	3	1
CO5	3	3	2	2	2	1	-	-	-	-	-	2	3	1

TEXT BOOKS:

1 D. Roy Choudhary, Sheil B. Jani, ‘Linear Integrated Circuits’, II edition, New Age, 2003.
2. Ramakant A.Gayakward, ‘Op-amps and Linear Integrated Circuits’, IV edition, Pearson Education, 2003 / PHI. 2000.
3. James W. Bignel, Digital Electronics, Cengage learning, 5th Edition, 2007
4. M. Morris Mano, ‘Digital Design with an introduction to the VHDL’, Pearson Education, 2013.

REFERENCE BOOKS:

1. David A. Bell, ‘Op-amp & Linear ICs’, Oxford, 2013
2. Comer “Digital Logic & State Machine Design, Oxford, 2012.

WEB RESOURCES:

1. Digital system design. https://nptel.ac.in/courses/108/106/108106177/

2. A BRIEF HISTORY OF ELECTRONICS

https://www.youtube.com/watch?v=IoDoW5kykkw&list=PLzJaFd3A7DZsA8xZg3tgoshboIIBY98cB

EE640303 - DC MACHINES AND TRANSFORMERS LABORATORY					
Course Category: Program Core	**Course Type: Practical**	**L**	**T**	**P**	**C**
		0	**0**	**3**	**1.5**

COURSE OBJECTIVES:

- To make the students to know about the operation, performance and Characteristics of D.C. machines and transformers by conducting various tests
- To enable the students to be familiar with the speed control of DC Motors
- To understand the working of DC motor starters

LIST OF EXPERIMENTS:

1. Open circuit and load characteristics of separately excited DC Generator.
2. Open circuit and load characteristics of self excited DC shunt Generator.
3. Load characteristics of DC compound generator with differential and cumulative connection
4. Load characteristics of DC shunt and compound motor
5. Load characteristics of DC series motor
6. Swinburne's test and speed control of DC shunt motor
7. Hopkinson's test on DC motor – generator set
8. Load test on single-phase transformer and three phase transformer connections
9. Open & short circuit test and polarity tests on single phase transformer.
10. Parallel Operation of Transformers
11. Sumpner's test on transformers
12. Separation of no-load losses in single phase transformer
13. Study of D.C motor starters

TOTAL: 45 PERIODS

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

CO1:Determine the performance characteristics of separately excited DC generators for different operating conditions

CO2:Determine the performance characteristics of self excited DC generators for different operating conditions

CO3:.Determine the performance characteristics of DC motors for different operating conditions

CO4: Determine the performance characteristics and parameters of Transformers under different operating conditions

CO5:Separate no load losses of Transformers

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	1	-	-	-	-	-	3	3	3	1	3	2
CO2	3	2	1	1		1	2		3	3	3	1	3	2
CO3	3	1	1	1		1	2		3	3	3	1	3	2
CO4	3	2	1	1	-	1	2		3	3	3	1	3	2
CO5	3	3	1	1	-	1	2		3	3	3	1	3	2

1- Low, 2 - Medium, 3 - High, '-' No Correlation

EE640304 - LINEAR AND DIGITAL CIRCUITS LABORATORY

Course Category: Program Core	Course Type: Practical	L	T	P	C
		0	0	3	1.5

COURSE OBJECTIVES:

- To learn design, testing and characterizing of circuit behaviour with digital and analog ICs.

LIST OF EXPERIMENTS:

1. Study and Operation of IC testers, pulse generator and digital trainer.
2. Measurement of Op Amp parameters
3. Op Amplifier applications
4. Op Amp Multivibrators.
5. 555 Timer as Multivibrators
6. Linear Voltage Regulator
7. Combinational Logic Circuits
8. Characteristics of TTL NAND gate:
9. Adders, Multiplexers and Decoders
10. Study of Flip-flops
11. Applications of Counter ICs
12. Applications of Registers

TOTAL: 45 PERIODS

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

CO1: Understand the integrator and differentiator.

CO2: Understand the characteristics of IC 555

CO3: Design and implement 4-bit shift registers

CO4: Design and implement counters using specific counter IC.

CO5: Design and implement the Mux and De-Mux

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	-	-	-	-	-	-	-	2	3	1
CO2	2	2	2	-	-	-	-	-	-	-	-	1	3	1
CO3	3	2	3	2	2	2	-	-	1	-	-	2	3	1
CO4	2	3	2	2	-	-	-	-	-	-	2	2	3	1
CO5	3	3	2	2	2	1	-	-	-	-	-	2	3	1

1- Low, 2 - Medium, 3 - High, '-' No Correlation

PROGRAM ELECTIVE COURSES: VERTICLES

VERTICLE 1 – POWER ENGINEERING

EE606101- CONVENTIONAL AND ALTERNATE ENERGY SOURCES

Course Category: Program Elective	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To introduce students to different aspects of power plant engineering.
- To familiarize the students to the working of power plants based on different fuels.
- To expose the students to the principles of safety and environmental issues.

UNIT 1: INTRODUCTION **9**

Power and energy, sources of energy, review of thermodynamic cycles related to power plants, fuels and combustion calculations. Load estimation, load curves, various terms and factors involved in power plant calculations. Effect of variable load on power plant operation, Selection of power plant. Power plant economics and selection: Effect of plant type on costs, rates, fixed elements, energy elements, customer elements and investor's profit; depreciation and replacement, theory of rates. Economics of plant selection, other considerations in plant selection.

UNIT 2: STEAM POWER PLANT **9**

General layout of steam power plant, Power plant boilers including critical and super critical

boilers. Fluidized bed boilers, boilers mountings and accessories, Different systems such as coal handling system, pulverizes and coal burners, combustion system, draft, ash handling system, Dust collection system, Feed water treatment and condenser and cooling towers and cooling ponds, Turbine auxiliary systems such as governing, feed heating, reheating, flange heating and gland leakage. Operation and maintenance of steam power plant, heat balance and efficiency, Site selection of a steam power	
UNIT 3: DIESEL POWER PLANT	**9**
General layout, Components of Diesel power plant, Site selection of diesel power plant, Comparative study of diesel power plant with steam power plant. Gas turbine power plant: Layout of gas turbine power plant, Elements of gas turbine power plants, Site selection of gas turbine power plant.	
UNIT 4: NUCLEAR POWER PLANT	**9**
Nuclear power plant: Principles of nuclear energy, Lay out of nuclear power plant, Basic components of nuclear reactions, nuclear power station, Nuclear waste disposal, Site selection of nuclear power plants. Hydroelectric station Hydrology, Principles of working, applications, site selection, classification and arrangements, hydro-electric plants, run off size of plant and choice of units, operation and maintenance, hydro systems, interconnected systems.	
UNIT 5: NON-CONVENTIONAL POWER PLANTS AND ELECTRICAL SYSTEM	**9**
Non-Conventional Power Plants Introduction to non-conventional power plants (Solar, wind, geothermal, tidal) etc. Generators and their cooling, transformers and their cooling. Instrumentation Purpose, classification, selection and application, recorders and their use, listing of various control rooms. Pollution due to power generation.	
TOTAL: 45 PERIODS	
COURSE OUTCOMES: At the end of the course, the student will be able to	
CO1: Describe and analyze different types of sources and mathematical expressions related to thermodynamics and various terms and factors involved with power plant operation.	
CO2: Analyze the working and layout of steam power plants and the different systems comprising the plant and discuss about its economic and safety impacts	
CO3: Combine concepts of previously learnt courses to define the working principle of diesel power plant, its layout, safety principles and compare it with plants of other types.	
CO4: Describe the working principle and basic components of the nuclear power plant and	

the economic and safety principles involved with it.

CO5: Discuss and analyze the mathematical and working principles of different electrical equipment involved in the generation of power.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	3	2	1	-	-	-	-	-	-	2	1	1
CO2	2	3	2	2	2	-	-	-	-	-	-	2	2	2
CO3	3	3	2	2	1	-	-	-	-	-	-	2	1	2
CO4	2	2	2	2	1	-	-	-	-	-	-	3	2	2
CO5	2	3	2	2	1	-	-	-	-	-	-	2	1	1

TEXT BOOKS:

1. Bedalov, Zark. Practical Power Plant Engineering: A Guide for Early Career Engineers. United Kingdom, Wiley, 2020.

2. Nag, P. K. Power Plant Engineering. India, McGraw-Hill Education (India) Pvt Limited, 2008.

REFERENCE BOOKS:

1. Zabihian, Farshid. Power Plant Engineering. United States, CRC Press, 2021.

2. Bowman, Seth N., and Bowman, Charles F. Thermal Engineering of Nuclear Power Stations: Balance-of-Plant Systems. United States, CRC Press, 2020.

WEB RESOURCES:

1. Power Plant Engineering. https://onlinecourses.nptel.ac.in/noc21_me86/preview

2. Steam power plant cycle. https://archive.nptel.ac.in/courses/112/107/112107291/

EE606102- GENERATION AND UTILIZATION OF ELECTRICAL ENERGY

Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To introduce various electric drives and their applications
- To discuss different methods of electrical heating and electric welding.
- To explain various techniques for designing indoor &outdoor lighting schemes
- To illustrate the fundamentals on electrolytic and electrometallurgical

UNIT 1: ELECTRIC DRIVES **9**

Advantages of electric drives, Characteristics of different mechanical loads, Parts of electric

drives electric motors, close loop of electric drive system, Types of motors used in electric drive pulley drives etc., Examples of selection of motors for different types of domestic loads, Selection of drive for applications such as general workshop, textile mill, paper mill, steel mill, printing press, crane and lift etc.	
UNIT 2: ILLUMINATION	**9**
Nature of light, visibility spectrum curve of relative sensitivity of human eye and wave length of light, Definition: Luminous flux, solid angle, luminous intensity, illumination, luminous efficiency, depreciation factor, coefficient of utilization, space to height ratio, reflection factor, glare, shadow, lux, Laws of illumination, Different type of lamps, construction and working of incandescent and discharge lamps – their characteristics, fittings required for filament lamp, mercury vapour lamp, fluorescent lamp, metal halide lamp, neon lamp, Main requirements of proper lighting; absence of glare, contrast and shadow, General ideas bout street lighting, flood lighting, monument lighting and decorative lighting, light characteristics etc.	
UNIT 3: ELECTRIC HEATING	**9**
Advantages of electrical heating, Heating methods: Resistance heating – direct and indirect resistance heating, electric ovens, their temperature range, properties of resistance heating elements, domestic water heaters and other heating appliances and thermostat control circuit, Induction heating; principle of core type and coreless induction furnace, Electric arc heating; direct and indirect arc heating, construction, working and applications of arc furnace	
UNIT 4: ELECTRIC WELDING	**9**
Advantages of electric welding, Welding method, Principles of resistance welding, types, Principle of arc production, electric arc welding, characteristics of arc; carbon arc, metal arc, hydrogen arc welding method of and their applications.	
UNIT 5: DESIGN AND DEVELOPMENT SMART ELECTRICAL HEATING	**9**
Electrical Circuits used in Refrigeration and Air Conditioning and Water Coolers: Principle of air conditioning, vapour pressure, refrigeration cycle, eco-friendly Refrigerants, Electrolytic Processes, Laws of electrolysis, process of electro-deposition - clearing, operation, deposition of metals, polishing, buffing.	
TOTAL: 45 PERIODS	
COURSE OUTCOMES: At the end of the course, the student will be able to	
CO1: Investigate on the various essential requirements and acquire the ability to design a safe and cost-effective electric traction system	

CO2: Judge the suitability of different motor drives to be used for a specific purpose

CO3: Review, analyse, and control the operation of various electric appliances used

CO4: Develop, select, and apply appropriate techniques for designing indoor & outdoor lighting schemes

CO5: Create, select, and apply appropriate techniques, tools and resources in designing/developing electrolytic and electrometallurgical processes

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	3	2	1							2	1	1
CO2	2	3	2	2	2							2	2	2
CO3	3	3	2	2	1							2	1	2
CO4	2	2	2	2	1							3	2	2
CO5	2	3	2	2	1							2	1	1

TEXT BOOKS:

1. Chaudhari, M. A. UTILIZATION OF ELECTRICAL ENERGY. India, Nirali Prakashan, 2020.

2. Kamran, Muhammad, and Fazal, Muhammad Rayyan. Renewable Energy Conversion Systems. United Kingdom, Elsevier Science, 2021.

REFERENCE BOOKS:

1. Electric Power Generation, Transmission, and Distribution. United Kingdom, CRC Press, 2018.

WEB RESOURCES:

1. Photovoltaic Power Generation.
https://www.digimat.in/nptel/courses/video/108105058/L19.html

2. Electric Energy Systems A Perspective.
https://nptel.ac.in/courses/108102047

EE606103-TRANSMISSION AND DISTRIBUTION

Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

To impart knowledge about the organization of the electrical power systems.

To learn the line parameters and intervention with nearest circuits.

To know the mechanical design and performance analysis of transmission lines.

To study about various types of insulators and underground cables.

To realize and know about the distribution system.

UNIT I BASICS OF AC AND DC TRANSMISSION SYSTEM	9

Structure of electric power system – Present Power Scenario in India, Extra High Voltage AC (EHVAC) Transmission – need, advantages, limitations –Effect of high voltage on volume of conductor and on efficiency -High Voltage Direct current Transmission (HVDC) – principle – classifications- advantages and limitations – Comparison between EHVAC and HVDC transmission -Examples of EHVAC and HVDC links. Mechanical design of transmission line between towers – sag and tension calculations using approximate equations taking into account the effect of ice and wind.

UNIT II TRANSMISSION LINE PARAMETERS	9

Parameters of resistance- inductance and capacitance calculations - single and three phase transmission lines - single and double circuits - solid- stranded and bundled conductors - symmetrical and unsymmetrical spacing – transposition of lines - concepts of GMR and GMD.-(Simple diagrams of typical towers and conductors for 400, 220 and 110 KV operations)

UNIT III MODELLING AND PERFORMANCE OF TRANSMISSION LINES	9

Transmission line classification - short line- medium line and long line – equivalent circuits – Ferranti effect - surge impedance- attenuation constant and phase constant - voltage regulation and transmission efficiency - real and reactive power flow in lines – power circle diagrams – shunt and series compensation. Corona**:** Introduction, disruptive critical voltage, corona loss, Factors affecting corona loss and methods of reducing corona loss, Disadvantages of corona, interference between power and Communication lines. Numerical problems in corona.

UNIT IV INSULATORS AND CABLES	9

Classification of insulators for transmission and distribution purpose – insulating materials -voltage distribution in insulator string and grading - improvement of string efficiency. Underground cables - constructional features of LT and HT cables – Overhead lines versus underground cables- types of cables - insulation resistance- Capacitance of a single core and three core cables - dielectric stress and grading.

UNIT V DISTRIBUTION SYSTEM	9

Feeders - distributors and service mains- DC 2-wire distributor – radial and ring main distribution. AC distribution – single phase (with concentrated and distributed loads) and three phase 3-wire and 4-wire distribution with balanced and unbalanced loads.

TOTAL: 45 PERIODS

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

CO1: Understand the structure of power system.

CO2: Compute the value of transmission line parameters.

CO3: Design and analyze the performance of Transmission lines.

CO4: Analyse the performance of insulators and cables.

CO5: Describe the modelling, performance analysis and modern trends in distribution systems.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	1	2	2	-	1	2	1	3	3	1
CO2	3	3	2	2	1	2	2	-	1	2	1	3	3	1
CO3	3	2	2	2	1	2	2	-	1	2	1	3	3	1
CO4	3	2	2	2	1	2	2	-	1	2	1	3	3	1
CO5	3	2	2	2	1	2	2	-	1	2	1	3	3	1

TEXT BOOKS:

1. V.K.Mehta, Rohit Mehta, “Principles of Power System”, S. Chand, New Delhi, 4th revised edition, 2018.

2. S.L. Uppal, “Electrical Power” Khanna Publishers, 13th edition, 2014.

REFERENCE BOOKS:

1. Hadi Saadat, “Power System Analysis,” Tata McGraw Hill Publishing Company”, 2nd edition, 2018.

2. S.N. Singh, “Electric Power Generation, Transmission and Distribution”, Prentice Hall of India Pvt. Ltd, New Delhi, Fourth printing, 2015.

3. C.L.Wadhwa, “Electrical power system”, New Age International, First Edition, 2016.

WEB RESOURCES:

1. Electric Energy Systems A Perspective. https://nptel.ac.in/courses/108/102/108102047/

2. https://nptel.ac.in/content/storage2/courses/108105053/pdf/L-2(TB)(ET)

((EE)NPTEL).pdf

EE606104-FLEXIBLE AC TRANSMISSION SYSTEMS					
Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To introduce students basics of power flow control and compensation
- To impart knowledge on FACTS technology, Variable impedance type and converter type shunt and series compensators, Operation of versatile FACTS devices.
- To expose the students Features of FACTS projects around the world and FACTS controller co-ordination.

UNIT-I GENERAL SYSTEM CONSIDERATION AND BASICS OF FACTS CONCEPTS	**9**

Active & Reactive Power flow between Two synchronous sources in AC Systems - Constraints of maximum transmission line loading – Relative importance of controllable parameters. Compensation - Uncompensated line, shunt compensation. Series compensation, Effect of compensation on power transfer capacity. Definition and types of FACTS controllers - Benefits of FACTS Technology

UNIT-II VARIABLE IMPEDANCE BASED STATIC SHUNT COMPENSATORS	**9**

Objectives of shunt compensation – Variable Impedance type static VAR generators: Operation, control and characteristics of TCR, TSR, TSC, FC-TCR and TSC-TCR- Functional control scheme for the FC-TCR and TSC-TCR type static VAR generator

UNIT- III VARIABLE IMPEDANCE BASED STATIC SERIES COMPENSATION	**9**

Objectives of series compensation–Need for Variable-Series Compensation-Variable impedance type series compensator: Operation, control, characteristics and control schemes of TSSC and TCSC

UNIT -IV CONVERTER BASED COMPENSATORS	**9**

STATCOM: Operation and VI Characteristics-Control Scheme for STATCOM- Comparison between SVC and STATCOM- SSSC – Capability, control range and VA

rating-Control Scheme for SSSC- Features of SSSC-UPFC: Basic operating principle-IPFC : Basic operating principle

UNIT 5: INSTALLATION OF FACTS CONTROLLERS & CO-ORDINATION ASPECTS **9**

Introduction , planning aspects, operational aspects and results of Slatt's TCSC, Sullivan's STATCOM-Introduction to Co-ordination of FACTS controllers-Controller Interactions-Different interaction between FACTS controllers: Steady state interactions, electro mechanical interaction, Small signal interaction, SSR interaction, High frequency interaction

TOTAL: 45 PERIODS

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

CO1: Demonstrate the importance of compensation and appropriate compensators.

CO2: Explain functions and capabilities of variable impedance based shunt compensators

CO3: Explain functions and capabilities of series compensation FACTS devices

CO4: Describe the functions and capabilities of converter based compensators

CO5: Address the need for FACTS controller co-ordination.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	3	2	1							2	3	3
CO2	2	3	2	2	2							2	3	3
CO3	3	3	2	2	1							2	3	3
CO4	2	2	2	2	1							3	3	3
CO5	2	3	2	2	1							2	3	3

TEXT BOOKS:

1. N.G. Hingorani& L. Gyugyi, "Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems" IEEE Press, 2000

2. R. Mohan Mathur, Rajiv K. Varma, "Thyristor-Based FACTS Controllers for Electrical Transmission Systems", IEEE press and John Wiley & Sons, 2002.

REFERENCE BOOKS:

1. Y.H. Song & A.T. John, "Flexible AC Transmission Systems (FACTS)", Book,IEE Power and Energy Series, 2000.

2. Padiyar K.R., "FACTS Controllers in Power Transmission and Distribution", New Age International, First Edition, Reprint 2013.

WEB RESOURCES:
1. Flexible ac transmission system. https://onlinecourses.nptel.ac.in/noc23_ee58
2. Flexible-ac-transmission-system-need-definition-types. https://www.elprocus.com

EE606105-HIGH VOLTAGE ENGINEERING					
Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**
COURSE OBJECTIVES:					

To impart knowledge on the following Topics

- Various types of over voltages in power system and protection methods.
- Generation of over voltages in laboratories.
- Measurement of over voltages.
- Nature of Breakdown mechanism in solid, liquid and gaseous dielectrics.
- Testing of power apparatus and insulation coordination

UNIT-I OVER VOLTAGES IN ELECTRICAL POWER SYSTEMS	**9**

Causes of over voltages and its effects on power system – Lightning, switching surges and temporary over voltages, Corona and its effects – Bewley lattice diagram- Protection against over voltages.

UNIT-II DIELECTRIC BREAKDOWN	**9**

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

UNIT- III GENERATION OF HIGH VOLTAGES AND HIGH CURRENTS	**9**

Generation of High DC voltage: Rectifiers, voltage multipliers, vandigraff generator: generation of high impulse voltage: single and multistage Marx circuits – generation of high AC voltages: cascaded transformers, resonant transformer and tesla coil- generation of switching surges – generation of impulse currents - Triggering and control of impulse generators.

UNIT -IV MEASUREMENT OF HIGH VOLTAGES AND HIGH CURRENTS	**9**

High Resistance with series ammeter – Dividers, Resistance, Capacitance and Mixed dividers - Peak Voltmeter, Generating Voltmeters - Capacitance Voltage Transformers,

Electrostatic Voltmeters – Sphere Gaps - High current shunts- Digital techniques in high voltage measurement.

UNIT 5: HIGH VOLTAGE TESTING & INSULATION COORDINATION | **9**

High voltage testing of electrical power apparatus as per International and Indian standards – Power frequency, impulse voltage and DC testing of Insulators, circuit breakers, bushing, isolators and transformers- Insulation Coordination& testing of capabilities

TOTAL: 45 PERIODS

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

CO1: Ability to understand Generation and measurement of high voltage.

CO2: Ability to understand High voltage testing.

CO3: Ability to understand various types of over voltages in power system.

CO4: Ability to measure over voltages.

CO5: Ability to test power apparatus and insulation coordination

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	1						1	1	1	1
CO2	3	2	2	2	2						1	2	2	2
CO3	2	2	2	2	1						2	2	1	2
CO4	2	2	2	2	1						2	3	2	2
CO5	2	3	2	2	1						1	2	1	1

TEXT BOOKS:

1. 1. S.Naidu and V. Kamaraju, ‘High Voltage Engineering’, Tata McGraw Hill, Fifth Edition, 2013.

2. E. Kuffel and W.S. Zaengl, J.Kuffel, ‘High voltage Engineering fundamentals’, Newnes Second Edition Elsevier , New Delhi, 2005.

3. C.L. Wadhwa, ‘High voltage Engineering’, New Age International Publishers, Third Edition, 2010.

REFERENCE BOOKS:

1. “L.L. Alston, ‘High Voltage Technology’, Oxford University Press, First Indian Edition, 2011.

2. Mazen Abdel – Salam, Hussein Anis, Ahdab A-Morshedy, Roshday Radwan, High Voltage Engineering – Theory & Practice, Second Edition Marcel Dekker, Inc., 2010.

3. Subir Ray,’ An Introduction to High Voltage Engineering’ PHI Learning Private Limited, New Delhi, Second Edition, 2013.

WEB RESOURCES:
1. High voltage DC Transmission https://archive.nptel.ac.in/courses/108/104/108104013/
2. Generation of High Test voltages https://archive.nptel.ac.in/courses/108/104/108104048/

EE606106-POWER SYSTEM TRANSIENTS					
Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To study the generation of switching transients and their control using circuit – theoretical concept.
- To study the mechanism of lighting strokes and the production of lighting surges.
- To study the propagation, reflection and refraction of travelling waves.
- To study the impact of voltage transients caused by faults, circuit breaker action, load rejection on integrated power system.

UNIT-I INTRODUCTION AND SURVEY	**9**

Source of transients, various types of power systems transients, effect of transients on power systems, importance of study of transients in planning.

UNIT-II SWITCHING TRANSIENTS	**9**

Introduction, circuit closing transients: RL circuit with sine wave drive, double frequency transients, observations in RLC circuit and basic transforms of the RLC circuit. Resistance switching: Equivalent circuit for the resistance switching problems, equivalent circuit for interrupting the resistor current. Load switching: Equivalent circuit, waveforms for transient voltage across the load, switch; normal and abnormal switching transients. Current suppression, current chopping, effective equivalent circuit. Capacitance switching, effect of source regulation, capacitance switching with a restrike, with multiple restrikes, illustration for multiple restriking transients, ferro resonance.

UNIT- III LIGHTNING TRANSIENTS	**9**

Causes of over voltage, lightning phenomenon, charge formation in the clouds, rate of charging of thunder clouds, mechanisms of lighting strokes, characteristics of lightning strokes; factors contributing to good line design, protection afforded by ground wires, tower footing resistance. Interaction between lightning and power system: Mathematical model for lightning.

UNIT -IV TRAVELLING WAVES ON TRANSMISSION LINE COMPUTATION OF TRANSIENTS	9
Computation of transients: Transient response of systems with series and shunt lumped parameters and distributed lines. Travelling wave concept: step response, Bewely's lattice diagram, standing waves and natural frequencies, reflection and refraction of travelling waves.	
UNIT 5: TRANSIENTS IN INTEGRATED POWER SYSTEM	**9**
The short line and kilometric fault, distribution of voltage in a power system: Line dropping and load rejection; voltage transients on closing and reclosing lines; over voltage induced by faults; switching surges on integrated system; EMTP for transient computation.	
TOTAL: 45 PERIODS	
COURSE OUTCOMES: At the end of the course, the student will be able to	
CO1: Ability to understand and analyse switching and lightning transients.	
CO2: Ability to acquire knowledge on generation of switching transients and their control.	
CO3: Ability to analyse the mechanism of lighting strokes.	
CO4: Ability to understand the importance of propagation, reflection and refraction of travelling waves.	
CO5: Ability to find the voltage transients caused by faults and to understand the concept of circuit breaker action, load rejection on integrated power system.	

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	1						1	1	1	1
CO2	3	2	2	2	2						1	1	2	2
CO3	2	2	2	2	2						2	1	1	1
CO4	2	2	2	2	2						2	2	2	2
CO5	2	3	2	2	1						1	2	1	1

TEXT BOOKS:

1. Allan Greenwood, 'Electrical Transients in Power Systems', Wiley Interscience, New York, 2nd edition 1991.

2. R.D.Begamudre, 'Extra High Voltage AC Transmission Engineering', Wiley Eastern Limited, 1986.

REFERENCE BOOKS:

1. M.S.Naidu and V.Kamaraju, 'High Voltage Engineering', Tata McGraw Hill, 2nd

edition, 2000.
WEB RESOURCES:
1. Power System Engineering. https://nptel.ac.in/courses/108105104
2. Power System Stability and Control. https://nptel.ac.in/courses/108106026

EE606107- POWER QUALITY					
Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**
COURSE OBJECTIVES:					

- To introduce students Different Power Quality Problems, Sources and mitigation of voltage sag and interruption
- To impart knowledge on Sources of harmonics and power under harmonic condition and Mitigation of harmonics
- To expose the students on Benchmarking process and power quality monitoring

UNIT-I INTRODUCTION	**9**
Terms and definitions: Transients, short duration and long duration voltage variations, Voltage imbalance, waveform distortion, Voltage fluctuations, Power frequency variation- Power acceptability curves: Computer Business Equipment Manufacturers Associations (CBEMA) curve	
UNIT-II VOLTAGE SAGS AND INTERRUPTIONS	**9**
Sources of sags and interruptions – Estimation of sag magnitude in radial systems: Influence of fault distance, Transformer, area of cross section of conductor-Estimation of voltage sag due to Induction Motor Starting Estimating voltage sag Performance using: Area of Vulnerability Equipment, Sag ride through capability curves ,Voltage Tolerance Ranges for different equipment - Mitigation of voltage sag at End user Level: Ferro resonant Transformer, Active series compensators, UPS, SMES, Static Transfer switch	
UNIT- III HARMONICS	**9**
Harmonics and its types-Harmonics versus Transients- Voltage distortion from current distortion-Harmonic indices: THD,IHD,TDD and Related Problems-Power Systems Quantities under Non-sinusoidal Condition: Sinusoidal Voltage Source Supplying Non-linear Load Current-Non-sinusoidal Voltage Source Supplying Non-linear Loads-Distortion Power factor-True Power factor- System Response characteristics to harmonics: System	

Impedance, capacitor impedance, parallel resonance and series resonance

UNIT -IV SOURCES, EFFECTS AND MITIGATION OF HARMONICS **9**

Harmonic sources from commercial and industrial loads – Effect of Harmonics on Transformer, AC motors, Capacitor banks, Protective Devices, Energy and demand Metering- k-factor of Transformer-Capacitor Bank Evaluation for IEEE standard for Shunt Power Capacitor-Harmonic Evaluation-Devices for controlling Harmonic Distortion: In-line Reactor, Zigzag Transformers, Passive filters, Active filters- Standards on Harmonics.

UNIT-V POWER QUALITY BENCH MARKING AND MONITORING **9**

Power Quality Indices: SAIFI, SAIDI, CAIDI and SARFI -Benchmarking Process- Power Quality Contracts-Power Quality Insurance- Power Quality Monitoring: Objectives and considerations

TOTAL: 45 PERIODS

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

CO1: List and Identify different Power Quality problems.

CO2: Describe about different sources for Voltage sag problem and its mitigation Techniques

CO3: Estimate the harmonic indices and Calculate Power system quantities under non-sinusoidal condition

CO4: Illustrate about different sources for Harmonics and its mitigation techniques

CO5: Explain about Power quality monitoring techniques and benchmark process.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	3	2	1							2	3	3
CO2	2	3	2	2	2							2	3	3
CO3	3	3	2	2	1							2	3	3
CO4	2	2	2	2	1							3	3	3
CO5	2	3	2	2	1							2	3	3

TEXT BOOKS:

1. Roger.C.Dugan, Mark.F.McGranagham, Surya Santoso, H.Wayne Beaty, “Electrical Power Systems Quality”, McGraw Hill Publishing Company Ltd, New Delhi, Third Edition, 2013.

2. Math H.J.Bollen, “Understanding Power Quality Problems-Voltage Sag & Interruptions”, (New York: IEEE press, 2000).

3. Arindam Ghosh and Gerard Ledwich, "Power Quality Enhancement Using Custom Power Devices", Springer International Edition, 2002

REFERENCE BOOKS:

1. C.Sankaran, "Power Quality", CRC press, 2002.

2. .Arrilaga, N.R.Watson, S.Chen, " Power System Quality Assessment", John Wiley & Sons, 2000

WEB RESOURCES:

1. NPTEL Course on Power Quality in Power Distribution Systems. http://nptel.ac.in/courses/108106025/)

2. Power Quality. https://electricalworkbook.com/power-quality/

EE606108-POWER SYSTEM PLANNING

Course Category: Program Core	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To learn the basic concepts of reliability models
- To impart knowledge on reliability analysis on Generation and Transmission system
- To expose the students approaches and distribution system planning.

UNIT-I LOAD FORECASTING **9**

Objectives of forecasting - Load growth patterns and their importance in planning - Load forecasting Based on discounted multiple regression technique-Weather sensitive load forecasting-Determination of annual forecasting-Use of AI in load forecasting.

UNIT-II GENERATION SYSTEM RELIABILITY ANALYSIS **9**

Probabilistic generation and load models- Determination of LOLP and expected value of demand not served –Determination of reliability of ISO and interconnected generation systems.

UNIT- III TRANSMISSION SYSTEM RELIABILITY ANALYSIS **9**

Deterministic contingency analysis-probabilistic load flow-Fuzzy load flow probabilistic transmission system reliability analysis-Determination of reliability indices like LOLP and expected value of demand not served.

UNIT -IV EXPANSION PLANNING **9**

Basic concepts on expansion planning-procedure followed for integrate transmission system planning, current practice in India-Capacitor placer problem in transmission system and

radial distributions system.

UNIT -V DISTRIBUTION SYSTEM PLANNING OVERVIEW **9**

Introduction, sub transmission lines and distribution substations-Design primary and secondary systems-distribution system protection and coordination of protective devices.

TOTAL: 45 PERIODS

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

CO1: Study about the Load growth patterns and their importance in planning.

CO2: Learn about the Probabilistic generation and load models.

CO3: Study the concepts of Fuzzy load flow probabilistic transmission system reliability analysis

CO4: Study the procedure followed for integrate transmission system planning.

CO5: Learn the Distribution System Protection And Coordination of Protective Devices.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	3	2	1	1	1					2	3	3
CO2	2	3	2	2	2	1	1					2	3	3
CO3	3	3	2	2	1	1	1					2	3	3
CO4	2	2	2	2	1	1	1					3	3	3
CO5	2	3	2	2	1	1	1					2	3	3

TEXT BOOKS:

1. Advanced Technologies, Systems, and Applications II: Proceedings of the International Symposium on Innovative and Interdisciplinary Applications of Advanced Technologies (IAT). Germany: Springer International Publishing, 2018.

2. Schlabbach, Juergen., Rofalski, Karl-Heinz. Power System Engineering: Planning, Design, and Operation of Power Systems and Equipment. Germany: Wiley, 2014.

REFERENCE BOOKS:

1. AbuShikhah, Nazih., Elkarmi, Fawwaz. Power System Planning Technologies and Applications: Concepts, Solutions and Management. United States: Engineering Science Reference, 2012.

2. A. Bhuvanesh, “Generation Expansion Planning for Tamil Nadu: Aiming a Low Carbon Future”, Notion Press, 1st edition, 19 October 2021. ISBN-10: 1684871115, ISBN-13: 978-1684871117.

WEB RESOURCES:
1. Power system planning. https://www.nrel.gov/docs/fy08osti/42297.pdf
2. Central Electricity Authority. https://cea.nic.in/power-system-planning-appraisal-i-division/

EE606109-SMART GRID: BASICS TO ADVANCED TECHNOLOGIES

Course Category: Program Elective	Course Type: Theory	L	T	P	C
		3	0	0	3

ABOUT THE COURSE

This course covers the fundamental aspects of the smart grid and its application to the existing power system. It introduces state-of-the-art smart grid technologies like electric vehicles, AC/DC microgrids, energy storage, phasor measurement unit, cyber security, etc. In addition, the course talks about the trends, modeling, planning, operation, and control of energy storage technologies. Further, it discusses the architecture, operation, and control strategy of AC, DC, and hybrid AC-DC microgrids. This course also emphasizes on renewable energy sources integration into the present grid and microgrids, and further explores its operation, analysis, management, control, protection, and monitoring issues. The laboratory-scale demonstrations have been provided to validate a few concepts covered in this course.

PREREQUISITES: Basic Understanding of Power System and Power Electronics Engineering

INDUSTRY SUPPORT: State Power Transmission and Distribution Companies, DISCOMs, TRANSCOs, POWER GRID, Private Sector: ABB, Schneider, Siemens, etc.

Course Layout

Week 1: Introduction to Smart Grid-I.
Introduction to Smart Grid-II.
Architecture of Smart Grid system
Standards for Smart Grid system
Elements and Technologies of Smart Grid System-I

Week 2: Elements and Technologies of Smart Grid System-II
Distributed Generation Resources-I

Distributed Generation Resources-II

Distributed Generation Resources-III

Distributed Generation Resources-IV

Week 3: Introduction to energy storage devices

Different types of energy storage technologies

Analytical modelling of energy storage devices

Optimal sizing and siting of storages

Battery management system (BMS)

Week 4: Wide area Monitoring Systems-I

Wide area Monitoring Systems-II

Phasor Estimation-I

Phasor Estimation-II

Digital Relays for Smart Grid Protection

Week 5: Islanding Detection Techniques–I

Islanding Detection Techniques –II

Islanding Detection Techniques –III

Smart Grid Protection-I

Smart Grid Protection-II

Week 6: Smart Grid Protection-III

Smart Grid Protection-IV

Modelling of storage devices

Modelling of DC smart grid components

Operation and control of AC Microgrid-I

Week 7: Operation and control of AC Microgrid -II

Operation and control of DC Microgrid -I

Operation and control of DC Microgrid -II

Operation and control of AC-DC hybrid Microgrid -I

Operation and control of AC-DC hybrid Microgrid -II

Week 8: Phasor measurement unit placement

Cyber security and resiliency

Virtual inertia and ancillary support

Demand side management of smart grid

Demand Response Analysis of smart grid

Week 9: Demonstration of solar power generation

Demonstration of wind power generation

Demonstration of Battery Management System

Demonstration of EV charging system

Hierarchical control techniques in hybrid ac-dc microgrid

Week 10: Simulation and case study of AC Microgrid

Simulation and case study of DC Microgrid

Simulation and case study of AC-DC Hybrid microgrid

Demonstration of parallel inverter operation in AC microgrid

Harmonic effects and its mitigation techniques

Week 11: Energy management

Design of Smart Grid and Practical Smart Grid Case Study-I

Design of Smart Grid and Practical Smart Grid Case Study-II

System Analysis of AC/DC Smart Grid

Demonstration of grid-connected DC microgrid

Week 12: Demonstration of energy management in microgrid

Demonstration of PHIL experimentation for symmetric and asymmetric fault analysis of grid-connected DFIG wind turbine.

Demonstration of ancillary support from virtual synchronous generator

Demonstration on peak energy management using energy storage system.

Conclusions

Books and references

1. Smart power grids by A Keyhani, M Marwali.

2. Computer Relaying for Power Systems by ArunPhadke

3. Microgrids Architecture and control by Nikos Hatziargyriou

4. Renewable Energy Systems by Fang Lin Luo, Hong Ye

5. Voltage-sourced converters in power systems_ modelling, control, and applications by Amirnaser Yazdani, Reza Iravani"

WEB LINK:

1. Smart Grid: Basics to Advanced Technologies

https://onlinecourses.nptel.ac.in/noc23_ee60/preview

EE606110-RESTRUCTURED POWER SYSTEM					
Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- Describe the behaviour of deregulated markets in power system.
- Describe the technical and non-technical issues in deregulated power industry.
- Identify the methods of Local Marginal prices calculation in transmission and the function of financial transmission rights.
- Analyse the energy and ancillary services management in deregulated power industry.
- Discriminate the restructuring framework US and Indian power sectors

UNIT-I INTRODUCTION	**9**

Reasons for restructuring - Understanding the restructuring process - objectives of deregulation of various power systems across the world - Consumer behaviour - Supplier behavior - Market equilibrium - Short-run and Long-run costs - Various costs of production. The Philosophy of Market Models: Market models based on contractual arrangements - Market architecture -

UNIT-II TRANSMISSION CONGESTION MANAGEMENT	**9**

Importance of congestion management in deregulated environment - Classification of congestion management methods - Calculation of ATC - Non-market methods - Market based methods – Nodal pricing - Inter-zonal Intra-zonal congestion management - Price area congestion management - Capacity alleviation method.

UNIT- III LOCATIONAL MARGINAL PRICES AND FINANCIAL TRANSMISSION RIGHTS	**9**

Fundamentals of locational marginal pricing - Lossless DCOPF model for LMP calculation – Loss compensated DCOPF model for LMP calculation - ACOPF model for LMP calculation - Risk Hedging Functionality Of financial Transmission Rights - FTR issuance process - Treatment of revenue shortfall - Secondary trading of FTRs - Flow Gate rights - FTR and market power

UNIT -IV ANCILLARY SERVICE MANAGEMENT AND PRICING OF TRANSMISSION NETWORK	**9**

Types of ancillary services -Load-generation balancing related services - Voltage control

and reactive power support services - Black start capability service - Mandatory provision of ancillary services -Markets for ancillary services - Co-optimization of energy and reserve services – International comparison. Pricing of transmission network: wheeling - principles of transmission pricing - transmission pricing methods - Marginal transmission pricing paradigm - Composite pricing paradigm - loss allocation methods.

UNIT 5: MARKET EVOLUTION	**9**

US markets: PJM market - The Nordic power market - Reforms in Indian power sector: Framework of Indian power sector - Reform initiatives - availability based tariff (ABT) - The Electricity Act 2012 - Open Access issues - Power exchange

TOTAL: 45 PERIODS

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

CO1: Describe the requirement for deregulation of the electricity market and the principles of market models in power systems.

CO2: Analyze the methods of congestion management in deregulated power system

CO3: Analyze the locational marginal pricing and financial transmission rights

CO4: Analyze the ancillary services management

CO5: Differentiate the framework of US and Indian power sectors

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	2	1						1	1	1	1
CO2	3	2	2	2	2						1	1	2	2
CO3	2	2	3	2	2						2	1	1	1
CO4	2	2	3	2	2						2	2	2	2
CO5	2	3	3	2	1						1	2	1	1

TEXT BOOKS:

1. Mohammad Shahidehpour, Muwaffaq Alomoush, “Restructured Electrical Power Systems: Operation, Trading and Volatility” Marcel Dekker Pub., 2001.

2. Kankar Bhattacharya, Math H.J.Boolen, and JaapE. Daadler, "Operation Of Restructured Power Systems”, Kluwer AcademicPub., 2001.

REFERENCE BOOKS:

1. Paranjothi, S.R., “Modern Power Systems The Economics of Restructuring”, New Age

International Publishers, First Edition: 2017.
2. Sally Hunt, "Making competition work in electricity", John Willey and Sons Inc.2002.
3. Steven Stoft," Power System Economics: Designing Markets for Electricity", Wiley, 2002.

WEB RESOURCES:

1. A. Khaparde, A. R. Abhyankar, "Restructured Power Systems", NPTEL Course, https://nptel.ac.in/courses/108101005/

STREAM 2 – CONVERTERS AND DRIVES

EE660212-SOLID STATE DRIVES		
Course Category: Professional Core	**Course Type: Theory With Project**	**L: 3, T: 0, P: 0, C: 3**

COURSE OBJECTIVES:

- To impart the basic knowledge on the various drive mechanisms and methods for energy conservation of Electrical Drives.
- To analyse the operation of controlled rectifier and chopper fed DC Drives.
- To analyse and design the current and speed controllers for solid state DC motor drives.
- To apply power electronic converters to control the speed of DC motors and induction motors.
- To develop closed loop control strategies of drives.

UNIT 1: INTRODUCTION	**9**

Introduction: drive system, types, choice of electrical drives- Dynamics of electrical drives: fundamental torque equation, classification of load torques, components of load torques - multi-quadrant operation - equivalent values of drive parameters - steady state stability - modes of operation

UNIT 2: DC MOTOR DRIVES	**9**

DC motor Fundamental relations- Analysis of fed single-phase semi converter, single-phase full converter and three phase full converter separately excited DC motor with continuous conduction mode operation- Time ratio and current limit control of chopper- Chopper fed DC motor drives: single, two and four quadrant operations.

UNIT 3: DESIGN OF CONTROLLERS FOR DC DRIVES	**9**

Transfer function of separately excited DC motors - Closed loop control of armature and field control-Design of controllers: Current controller and speed controller - Converter selection and characteristics-PLL and microcomputer control of DC drives.

UNIT 4: INDUCTION MOTOR DRIVES	**9**

Introduction - Equivalent circuit, speed-torque characteristics, Steady state performance equations - Stator control: Stator Voltage Control - Constant Voltage Variable Frequency operation - Constant V/f operation - VSI and CSI fed induction motor drives and Closed loop control- Rotor control: Rotor resistance control - Qualitative treatment of slip power recovery scheme.

UNIT 5: SYNCHRONOUS MOTOR DRIVES AND SELECTION OF DRIVES	**9**

Wound field cylindrical rotor motor – Equivalent circuit– synchronous motors variable speed drives-separate control and self-controlled synchronous motor drive using load commutated thyristor inverter–Permanent magnet synchronous motor drives- Selection of drives: Textile mills, cement mills and paper mills.

TOTAL: 45 PERIODS

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

CO1: Demonstrate the importance of Electrical drives.

CO2: Design and analyse the operation of the various controlled rectifier and chopper fed DC drives.

CO3: Analyse and design the current and speed controllers for solid state DC motor drives.

CO4: Analyse the various speed control methods of induction motor drives.

CO5: Analyse the various speed control methods of synchronous motor drives and the selection of drives for industrial applications.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	

CO1	3	2	1	1	1	1			1		1	1	3	2
CO2	3	2	1	1	3	1			1		1	3	3	2
CO3	3	2	2	2	3	1			2		2	3	3	2
CO4	3	2	2	2	3	1			2		2	3	3	2
CO5	3	2	2	2	3	1			2		2	3	3	2

TEXT BOOKS:

1. Dubey G.K., "Fundamentals of Electrical Drives", Narosa Publishing House, Second Edition, 2015

2. Krishnan R., " Electric Motor & Drives: Modelling, Analysis and Control", Pearson Education, 2015

3. Pillai S.K., "A First Course on Electrical Drives", New Age International Publishers, Third Edition, 2013.

REFERENCE BOOKS:

1. Bimal K Bose, "Modern Power Electronics and AC Drives" Pearson Education, 2016

2. Vedam Subramanyam, "Electric Drives – Concepts and Applications", McGraw Hill, Second Edition, 2010

3. Muhammad H. Rashid, "Power Electronics: Circuits, Devices and Applications", Pearson Education, 4th Edition, 2017.

WEB RESOURCES:

1.Electric motors and drives:
https://www.academia.edu/37281136/Electric_Motors_and_Drives_book_pdf

2. Fundamental of Electric Drives video lectures:
https://www.bing.com/videos/search?q=electric+drives+nptel&qpvt=electric+drives+nptel&FORM=VDRE

EE606201- POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS

Course Category: Professional Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To learn the various types of renewable sources of energy.
- To understand the electrical machines to be used for wind energy conversion systems.
- To learn the principles of power converters used in solar PV system.
- To study the principle of power converters used in Wind system.
- To simulate the AC-DC, AC-AC Converters, Matrix Converters and PWM Inverters.

UNIT 1: INTRODUCTION TO RENEWABLE ENERGY SYSTEMS	**9**

Classification of Energy Sources – Importance of Non-conventional energy sources – Advantages and disadvantages of conventional energy sources - Environmental aspects of energy - Impacts of renewable energy generation on the environment - Qualitative study of renewable energy resources: Ocean energy, Biomass energy, Hydrogen energy, - Solar Photovoltaic (PV), Fuel cells: Operating principles and characteristics, Wind Energy: Nature of wind, Types, control strategy, operating area.

UNIT 2: ELECTRICAL MACHINES FOR WIND ENERGY CONVERSION SYSTEMS(WECS)	**9**

Construction, Principle of operation and analysis: Squirrel Cage Induction Generator (SCIG), Doubly Fed Induction Generator (DFIG) - Permanent Magnet Synchronous Generator (PMSG).

UNIT 3: POWER CONVERTERS AND ANALYSIS OF SOLAR PV SYSTEMS	**9**

Power Converters: Line commutated converters (inversion-mode) - Boost and buck-boost converters - selection of inverter, battery sizing, array sizing. Simulation of line commutated converters, buck/boost converters. Analysis: Block diagram of the solar PV systems - Types of Solar PV systems: Stand-alone PV systems, Grid integrated solar PV Systems - Grid Connection Issues. PWM Inverters, Grid Interactive Inverters-matrix converters.

UNIT 4: POWER CONVERTERS	**9**

Power Converters: Three-phase AC voltage controllers- AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters, Grid-Interactive Inverters - Matrix converter.

UNIT 5: HYBRID RENEWABLE ENERGY SYSTEMS	**9**

Need for Hybrid Systems- Range and type of Hybrid systems- Case studies of Diesel-PV, Wind PV, Micro hydel - PV, Biomass-Diesel systems - Maximum Power Point Tracking (MPPT).

TOTAL: 45 PERIODS

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

CO1: Examine the available renewable energy sources.

CO2: Demonstrate the working principles of electrical machines and power converters used for wind energy conversion system

CO3: Demonstrate the principles of power converters used for solar PV systems

CO4: Examine the available hybrid renewable energy systems.

CO5: Simulate AC-DC converters, buck/boost converters, AC-AC converters and PWM inverters.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2			
CO1	3		2							2		2	3	3			
CO2	3		2							2		2	3	3			
CO3	3		2							2		2	3	3			
CO4	3		3	3	3			3		2		2	3	3			
CO5	3	1	2	3	3			3		2		3	3	3			

REFERENCE BOOKS:

1. S.N.Bhadra, D. Kastha, & S. Banerjee “Wind Electrical Systems”, Oxford University Press, 2009, 7th impression.

2. Rashid .M. H “Power electronics Hand book”, Academic press,2nd Edition, 2006 4th Edition, 2017

3. Rai. G.D, “Non-conventional energy sources”, Khanna publishers, 6th Edition, 2017.

4. Rai. G.D,” Solar energy utilization”, Khanna publishers, 5th Edition, 2008.

5. Gray, L. Johnson, “Wind Energy System”, Prentice Hall of India, 2nd Edition, 2006.

6. 6. H.Khan "Non-conventional Energy sources ", Tata McGraw-Hill Publishing Company, New Delhi, 2017, 3rd Edition.

WEB RESOURCES:

1. MSG, SCIG and DFIG.
https://www.ijireeice.com/upload/2016/february-16/IJIREEICE%201.pdf

2. PV Maximum Power Point Tracking (MPPT)
https://www.solar-electric.com/learning-center/mppt-solar-charge-controllers.html/

EE606202- CONTROL OF POWER ELECTRONIC CIRCUITS

Course Category: Professional Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To learn the basics of control system simulation.
- To do symbolic calculation.
- To study the principles of sliding mode control and the way of apply SMC for buck converter.
- To learn the concept of power factor correction.
- To design simulate SMC for buck converter and power factor correction circuit with controller.

UNIT 1: SIMULATION BASICS IN CONTROL SYSTEMS **9**

Transfer Function-How to build transfer function, identify Poles, zeros, draw time response plots, bode plot (Bode Plots for Multiplication Factors, Constant, Single and Double Integration Functions, Single and Double Differentiation Functions, Single Pole and Single Zero Functions,/RHP Pole and RHP Zero Functions), state space modelling-transfer function from state space Model.

UNIT 2: SYMBOLIC CALCULATIONS **9**

Introduction, Linear Feedback Control- Pole Placement by Full State Feedback, Pole Placement Based on Observer Design, Reduced Order Observers, Generalized Proportional Integral Controllers Hamiltonian Systems Viewpoint - Application to power converters.

UNIT 3: SLIDING MODE CONTROL BASICS **9**

Introduction- Introduction to Sliding-Mode Control- Basics of Sliding-Mode Theory-Application of Sliding-Mode Control to DC-DC Converters—Principle-Sliding mode control of buck converter.

UNIT 4: POWER FACTOR CORRECTION CIRCUITS **9**

Introduction, Operating Principle of Single-Phase PFCs, Control of boost converter based PFCs, Designing the Inner Average-Current-Control Loop, Designing the Outer Voltage-Control Loop, Example of Single-Phase PFC Systems.

UNIT 5: CONTROLLER DESIGN FOR PFC CIRCUITS **9**

Power factor correction circuit using other SMPS topologies: C'uk and SEPIC converter - PFC circuits employing bridgeless topologies.

TOTAL: 45 PERIODS

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

CO1: To calculate transfer function for constant, differential, integral, First order and Second order factors.

CO2: To illustrate the effect of poles and zero's in the 's' plane.

CO3: To select Symbolic equations for solving problems related with Matrices, Polynomial and vectors.

CO4: To compute the control expression for DC – DC buck converter using sliding mode control theory.

CO5: To determine the controller expression for power factor correction circuits.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2		
CO1	3	3	3	3	3	-	-	1	-	2	-	3	3	3		
CO2	3	3	3	3	3	-	-	1	-	2	-	3	3	3		
CO3	3	3	3	3	3	-	-	1	-	2	-	3	3	3		
CO4	3	3	3	3	3	-	-	1	-	2	-	3	3	3		
CO5	3	3	3	3	3	-	-	1	-	2	-	3	3	3		

TEXT BOOKS:

1. Feedback Control problems using MATLAB and the Control system tool box By Dean Frederick and Joe Chow, 2000, 1st Edition, Cengage Learning.

2. Ned Mohan, "Power Electronics: A First Course", Johnwiley, 2013, 1st Edition.

3.Marian K. Kazimierczuk and Agasthya Ayachit,"Laboratory Manual for Pulse-Width Modulated DC-DC Power Converters", Wiley 2016, 1st Edition.

4. Power Electronics handbook, Industrial Electronics series, S.K.Varenina, CRC press, 2002, 1st Edition.

REFERENCE BOOKS:
Sliding mode control for Switching Power Converters:, Techniques and Implementation, Slew-Chong Tan, Yuk Ming Lai Chi-Kong Tse, 1st Edition, CRC Press.
2. Andre Kislovski, "Dynamic Analysis of Switching-Mode DC/DC Converters", Springer 1991.
3. MATLAB Symbolic Algebra and Calculus Tools, Lopez Cesar, Apress, 2014.
WEB RESOURCES:
1. Reduced Order Observers file:///C:/Users/user/Downloads/351_27435_EE515_2015_1__1_1_0%207%20EE515%20Lec7%20Reduced%20Order%20Observer.pdf
2. Power Factor Correction (PFC) Circuits https://toshiba.semicon-storage.com/info/application_note_en_20191106_AKX00080.pdf?did=68570

EE606203-DESIGN OF SWITCHED MODE POWER SUPPLY						
Course Category: Professional Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**	
		3	**0**	**0**	**3**	
COURSE OBJECTIVES:						
• To provide in depth knowledge about modelling, analysis and Design of switched mode power converters. • To analyze and design switch mode power electronic converters for various applications						
UNIT 1: INTRODUCTION						**9**
Reactive Elements in Power Electronic Systems - Design of inductor - Design of transformer - Capacitors for power electronic applications.						
UNIT 2: SWITCHED MODE POWER CONVERTERS						**9**
Switched Mode power converters : Buck Converter - Boost Converter - Buck-Boost Converter - Discontinuous Mode of Operation in dc to dc Converters - Isolated dc to dc Converters: Forward Converter - Push-Pull converter - Fly-back Converter.						
UNIT 3: ANALYSIS OF CONVERTERS						**9**

Pulse Width Modulated Converter: Averaged Model of the Converter - Steady State Solution - Small Signal Model of The Converter - Transfer Functions of the converter - Generalized State Space Model of the Converter - Linear Small signal Model - Dynamic functions of the Converter.

UNIT 4:SOFT SWITCHING CONVERTERS **9**

Resonant Load Converters - Principle of Operation - SMPS Using Resonant Circuit - Steady State Modeling of Resonant SMPS - Resonant Switch Converters - Buck Converter with Zero Current Switching- Conversion Ratio of the Converter - Boost Converter with Zero Voltage Switching - Resonant Transition Phase Modulated Converters - Boost Converter with Zero Voltage Switching - Design considerations to achieve ZVS - Resonant Switching Converters with Active Clamp.- Analysis of Active Clamp ZVS Buck Converter – Steady State Conversion Ratio.

UNIT 5:CURRENT CONTROL OF CONVERTERS **9**

Sub-harmonic Instability in Current Programmed Control - Determination of Duty Ratio for Current Programmed Control - Power Circuit of UPF Rectifiers - Average Current Mode Control - Resistor Emulator UPF Rectifiers.

TOTAL: 45 PERIODS

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

CO1: Design of magnetic components (i.e., inductor and transformer) in a converter

CO2: Analyse the Steady-state analysis of switched mode power supply

CO3: Obtain the Equivalent circuit Model for a switching power supply

CO4: Analyze the steady state Performance of soft switching converters

CO5: Describe the various current control switched mode power converter

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2			
CO1	3	1	1	2	3			1	2		1	2	2	2			
CO2	3	1	1	1	3			1	2		1	2	2	2			
CO3	3	2	2	2	3			1	2		1	2	3	2			
CO4	3	2	2	2	3			1	2		1	2	3	2			
CO5	3	2	2	2	3			2	2		1	2	3	2			

TEXT BOOKS:

1. Basso, C.P, Switch-mode power supplies, Second edition: Spice Simulations and Practical

Designs. United states: McGraw hill llc.2014.

2. Sandler, Steven M," switched-mode power supply simulation with spice", The Faraday Press Edition. United states, armchair adventurer, 2018.

3. Maniktala, Sanjaya, Switching Power Supplies A - Z. Germany, Elsevier Science, 2012.

REFERENCE BOOKS:

1. Lee, Computer-Aided Analysis and Design of Switch-Mode Power Supplies, United Kingdom, CRC Press, 2017.

2. S. S. Ang, A.Oliva, "Power Switching Converters", Marcel Dekker, 2nd edition. 2005.

3. Wu, Keng C, Switch-Mode Power Converters: Design and Analysis", Netherlands: Elsevier Science, 2005.

WEB RESOURCES:

1.Introduction to SMPS Control Techniques:
https://www.microchip.com/stellent/groups/SiteComm_sg/documents/Training_Tutorials/en528010.pdf

2. Switched mode Power conversion:
https://archive.nptel.ac.in/courses/108/108/108108036/

3. Design of switched mode power supply:
https://www.academia.edu/98582034/Design_of_a_Switch_Mode_Power_Supply_with_Soft_Switching_and_Analog_Control

EE606204- MULTILEVEL POWER CONVERTERS

Course Category: Professional Elective	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To learn multilevel topology (Symmetry & Asymmetry) with common DC bus link.
- To study the working of cascaded H Bridge, Diode Clamped and Flying Capacitor MLI.
- To study the working of MLI with reduced switch count.

- To simulate three level diode clamped MLI and three level flying capacitor based MLI with resistive and reactive load
- To simulate the MLI with reduced switch count.

UNIT 1: MULTILEVEL TOPOLOGIES	**9**

Introduction – Generalized Topology with a Common DC bus – Converters derived from the generalized topology – symmetric topology without a common DC link – Asymmetric topology.

UNIT 2: CASCADED H-BRIDGE MULTILEVEL INVERTERS	**9**

Introduction -H-Bridge Inverter, Bipolar Pulse Width Modulation, Unipolar Pulse Width Modulation. Multilevel Inverter Topologies, CHB Inverter with Equal DC Voltage, H-Bridges with Unequal DC Voltages – PWM, Carrier-Based PWM Schemes, Phase-Shifted Multicarrier Modulation, Level Shifted Multicarrier Modulation, Comparison Between Phase- and Level-Shifted PWM Schemes Staircase Modulation.

UNIT 3: DIODE CLAMPED MULTILEVEL CONVERTER	**9**

Introduction – Converter structure and Functional Description – Modulation of Multilevel converters– Voltage balance Control – Effectiveness Boundary of voltage balancing in DCMC converters –Performance results.

UNIT 4: FLYING CAPACITOR MULTILEVEL CONVERTER	**9**

Introduction – Flying Capacitor topology – Modulation scheme for the FCMC – Dynamic voltage balance of FCMC.

UNIT 5: MULTILEVEL CONVERTER WITH REDUCED SWITCH COUNT	**9**

Multilevel inverter with reduced switch count-structures, working principles and pulse generation methods.

TOTAL: 45 PERIODS

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

CO1: Examine the different topologies of multilevel inverters (MLIs) with and without DC link capacitor.

CO2: Examine the performance of MLIs with Bipolar Pulse Width Modulation (PWM) Unipolar PWM Carrier-Based PWM Schemes Phase Level Shifted Multicarrier Modulation

CO3: Demonstrate the working principles of Cascaded H-Bridge MLI, diode clamped MLI, flying capacitor MLI and MLI with reduced switch count

CO4: Analyze the voltage balancing performance in Diode clamped MLI.

CO5: Simulate three level, capacitor clamed and diode clamped MLI with R and RL load.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2			
CO1	3	2	2	3			2	1		3		3	3	3			
CO2	3	2	2	3			2	1		3		3	3	3			
CO3	3	2	2	3			2	1		3		3	3	3			
CO4	3	3	3	3			2	1		3		3	3	3			
CO5	3	3	3	3	3		2	1		3		3	3	3			

TEXT BOOKS:

1. Rashid M.H, ”Power Electronics Circuits, Devices and Applications”, Prentice Hall India, Third Edition, New Delhi, 2014 Pearson 4th edition.

2. Sergio Alberto Gonzalez, Santiago Andres Verne, Maria Ines Valla, ”Multilevel Converters for Industrial Applications”, CRC Press, 22-Jul-2013, 20171st Edition.

3. BinWu, Mehdi Narimani, High Power Converters and AC drives by IEEE press 2017, 2nd Edition.

REFERENCE BOOKS:

1. Thomas A. Lipo, Pulse Width Modulation for Power Converters: Principles and Practice, D.Grahame Holmes, John Wiley & Sons, Oct-2003, 1st Edition.

2. Fang Lin Luo, Hong Ye, Advanced DC/AC Inverters: Applications in Renewable Energy, CRC Press, 22-Jan-2013, 2017, 1st Edition.

3. Hani Vahedi, Mohamed Trabelsi, Single-DC-Source Multilevel Inverters, Springer, 2019, 1st Edition.

4. Ersan Kabalcı, Multilevel Inverters Introduction and Emergent Topologies, Academic Press Inc, 2021, 1st Edition.

5. Iftekhar Maswood, Dehghani Tafti, Advanced Multilevel Converters and Applications in Grid Integration, Wiley, 2018, 1st Edition.

WEB RESOURCES:

1.H- Bridge Inverter

https://www.electricaltechnology.org/2020/06/half-h-bridge-inverter-its-modes-of-operation-with-waveforms.html

2.Voltage balance control

https://ieeexplore.ieee.org/abstract/document/1542326

EE606205-DIGITAL SYSTEM DESIGN (NPTEL)

Course Category: Professional Elective	Course Type: Theory	L	T	P	C
		3	0	0	3

ABOUT THE COURSE

Digital system design course focuses on design digital system from scratch. The course focuses on designing combinational and sequential building blocks, using these building blocks to design bigger digital systems. During this course we also learn how to use Verilog to design/model a digital system.

INDUSTRIES SUPPORT: Any VLSI related company: Intel, AMD, TI, nVIDIA, Qualcomm, etc.

Course Layout

Week 1: Introduction of digital systems. Number system

Week 2: Number representation: BCD, floating point numbers

Week 3: Boolean algebra, application of Boolean algebra in minimization of Boolean expressions

Week 4: Boolean minimization using K-map and Quine McCluskey method. Introduction to Verilog

Week 5: MSI Logic: Multiplexer, encoder, decoder

Week 6: Arthimetic circuits: Adder, subtractor, multiplier, comparator

Week 7: Latches and flipflop (SR, JK, T, D), counters

Week 8: Sequential logic like Registers, introduction to behavior modeling in Verilog

Week 9: Finite state machine, state graphs and tables.

Week 10: Reduction of state table and state assignments. Arithmetic circuits using sequential design.

Week 11: Register transfer level (RTL) design, RTL design examples

Week 12: FPGA, VLSI design flow using HDL, introduction to behavior, logic and physical synthesis.

Books and References

1. Digital Design: with an introduction to Verilog HDL by M. Morris Mano and Mechael D. Ciletti, 5th Edition, Pearson Education, 2013.
2. Advanced Digital Design with the Verilog HDL by Michael D Ciletti, 2nd edition, Pearson education, 2017.
3. Fundamentals of Logic Design by Roth and Kinney. 7th edition, Cengage learning, 2014
4. Digital system design using verilog by Roth, John and Lee, 1st edition, Cengage learning, 2016.

WEB LINK:

Digital system design NPTEL course:

https://onlinecourses.nptel.ac.in/noc21_ee39/preview

EE606206-ADVANCED POWER ELECTRONICS		
Course Category: Professional Elective	**Course Type: Theory**	**L T P C** **3 0 0 3**
COURSE OBJECTIVES:		

- To impart knowledge on advancement in AC-DC conversion
- To understand the features and concept of multilevel inverter.
- To perceive the advancement in Modern DC-DC conversion.
- To design the modelling of DC-DC converter
- To grasp the knowledge on DC-DC converter dynamics.

UNIT 1: AC-DC CONVERSION	**9**

Generation of current harmonics from AC to DC converter- Harmonics standard and recommended practice-Need for improved utility Interface- Diode rectifier-fed boost converter -Working of Three phase PWM rectifier and its advantages- Interface for bidirectional power flow single phase and three phase

UNIT 2: MULTILEVEL INVERTER	**9**

Features of Multilevel inverter-Multilevel concept – Principle of operation and Features of: diode clamped, flying capacitor, cascade type multilevel inverters - Comparison of multilevel inverters - application of multilevel inverters

UNIT 3: ISOLATED DC-DC CONVERTERS **9**

Need for isolated DC-DC converter- Working principle and Derivation of output voltage for: Fly back converter, Forward converter, Push pull converter, half bridge converter and Full bridge converter

UNIT 4: MODERN DC-DC CONVERTERS **9**

CUK converter –SEPIC converter-Multi output boost converter-L-Type ZCS Resonant converter-M-type ZCS Resonant converter-Zero voltage resonant converter

UNIT 5: DC- DC CONVERTER DYNAMICS **9**

Block diagram explanation of closed loop control of DC-DC Converter- Steps involved in state space averaging- Derivation of Transfer function of Ideal buck, boost converter using state space averaging- Converter Non Idealities

TOTAL: 45 PERIODS

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

CO1: Describe the need and working of active power factor correction techniques

CO2: Explain the working and compare different topologies of multilevel inverter

CO3: Illustrate the working of DC-DC converter.

CO4: Design the passive components for DC-DC converter for desired specification.

CO5: Obtain the state-space modelling of DC-DC converter.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2		
CO1	3	2	2	1	3				2		1	3	2	2		
CO2	3	2	2	1	3				2		2	3	2	2		
CO3	3	2	2	2	3				2		2	3	2	2		
CO4	3	2	2	2	3				2		2	3	2	2		
CO5	3	2	2	2	3				2		2	3	3	2		

TEXT BOOKS:

1. Ned Mohan, Tore M. Undeland, William P. Robbins, “Power Electronics - Converters, Applications and Design”, Wiley India, 3rd Edition, 2018.

2.Muhammad H.Rashid, “Power Electronics Circuits, Devices and Applications”, Pearson Publication, 4th Edition, 2017

REFERENCE BOOKS:

1. Robert W. Erickson, Dragan Maksimovic, “Fundamentals of Power Electronics”, Springer Science & Business Media, 2nd edition 2001.

WEB RESOURCES:

1. Advanced Power Electronics NPTEL lectures: https://archive.nptel.ac.in/courses/108/107/108107128/

2. Advanced Power Electronics lecture notes: https://sites.google.com/site/eeenotes2u/courses/advanced-power-electronics

3. Multilevel Inverters: https://microcontrollerslab.com/multilevel-inverters-types-applications/

EE606208-ANALYSIS OF ELECTRICAL MACHINES

Course Category: Professional Elective	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

• To impart knowledge on the fundamentals of circuits, energy, force and torque of single and multi-excited systems.

• To make the students analyze the steady state and dynamic state operation of a DC machine through mathematical modelling.

• To provide knowledge on transformation of three phase variables to two phase variables.

• To make the students analyze the steady state and dynamic state operation of three-phase induction machines & synchronous machines using transformation theory based mathematical modelling.

UNIT 1: PRINCIPLES OF ELECTROMECHANICAL ENERGY CONVERSION	**9**

Principles of Electromechanical Energy Conversion, General expression of stored magnetic energy, co-energy and force/torque, example using single and doubly excited system.

UNIT 2: DC MACHINES	**9**

Elementary DC machine and analysis of steady state operation - Voltage and torque equations – dynamic characteristics of permanent magnet and shunt DC motors – Time domain block diagrams - Solution of dynamic characteristic by Laplace transformation.

UNIT 3: REFERENCE FRAME THEORY **9**

Static and rotating reference frames – Equations of transformation: Change of variables – Stationary circuit variables transformed to arbitrary reference frame – Commonly used reference frames –Transformation between reference frames.

UNIT 4: INDUCTION MACHINES **9**

Three phase induction machine – Voltage and torque equations in machine variables and arbitrary reference frame variables – Analysis of steady state operation – Analysis of dynamic performance for load torque variations.

UNIT 5: SYNCHRONOUS MACHINES **9**

Three phase synchronous machine - Voltage and torque equations in machine variables and rotor reference frame variables (Park's equations) – Analysis of steady state operation - Analysis of dynamic performance for load torque variations.

TOTAL: 45 PERIODS

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

CO1: Calculate energy, force and torque for single and multi-excited systems.

CO2: Analyse the steady state and dynamic state operation of DC machine through mathematical modelling.

CO3: Analyse the theory of transformation of three phase variables to two phase variables.

CO4: Analyse the steady state and dynamic state operation of three-phase induction machines.

CO5: Analyse the steady state and dynamic state operation of synchronous machines.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2		
CO1	3	2	2	2	2			1				2	2	2		
CO2	3	2	2	2	2			1	1			2	2	2		
CO3	3	2	3	3	2			1	1			2	2	2		
CO4	3	2	3	3	2			1	1		1	2	2	2		
CO5	3	2	3	3	2			1	1		1	2	2	2		

TEXT BOOKS:
1. Paul C.Krause, Oleg Wasyzczuk, Scott S, Sudhoff, "Analysis of Electric Machinery and drive Systems", John Wiley, Second Edition, 2010.
2. D.P.Kothari, I.J.Nagrath," Electrical Machines", McGraw-Hill, Fifth edition, 2017.
3. Rafajdus, Pavol., Hrabovcova, Valeria., Makys, Pavol," Analysis of Electrical Machines", United Kingdom: IntechOpen, 2020.
REFERENCE BOOKS:
1. R. Krishnan, 'Electric Motor & Drives: Modelling, Analysis and Control', Prentice Hall of India Pvt. Ltd., New Delhi, 2003.
2. Ramanujam,R.,"Modelling and Analysis of Electrical Machines", India, I.K. International Publishing House Pvt. Limited, 2018.
3. P S Bimbhra, "Generalized Theory of Electrical Machines", Khanna Publishers, 2014.
WEB RESOURCES:
1. Modelling and analysis of Electric machines: https://archive.nptel.ac.in/courses/108/106/108106023/
2. Reference frame theory: https://home.engineering.iastate.edu/~jdm/ee554/LastTopics1.pdf
3. Electrical machines analysis & modelling: https://ocw.mit.edu/courses/6-685-electric-machines-fall-2013/pages/course-notes/

EE606209 - ANALYSIS OF POWER CONVERTERS					
Course Category: Professional Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**
COURSE OBJECTIVES:					

- To provide the mathematical fundamentals necessary for deep understanding of power converter operating modes.
- To provide the electrical circuit concepts behind the different working modes of power converters so as to enable deep understanding of their operation.
- To provide required skills to formulate and design inverters for generic load and for machine loads.

- To equip with required skills to derive the criteria for the design of power converters starting from basic fundamentals.
- To analyze and comprehend the various operating modes of different configurations of power converters

UNIT 1: SINGLE PHASE AC-DC CONVERTER	**9**

Static Characteristics of power diode, SCR and GTO, half controlled and fully controlled converters with R-L, R-L-E loads and freewheeling diodes – continuous and discontinuous modes of operation –Sequence control of converters– effect of source impedance and overlap

UNIT 2: THREE PHASE AC-DC CONVERTER	**9**

Semi and fully controlled converter with R, R-L, R-L-E - loads and freewheeling diodes – performance parameters – effect of source impedance and overlap-12 pulse converter

UNIT 3: SINGLE PHASE INVERTERS	**9**

Introduction to self-commutated switches : MOSFET and IGBT - Principle of operation of half and full bridge inverters – Performance parameters – Voltage control of single phase inverters using various PWM techniques – various harmonic elimination techniques – Design of UPS-VSR operation

UNIT 4: THREE PHASE INVERTERS	**9**

180 degree and 120 degree conduction mode inverters with star and delta connected loads –voltage control of three phase inverters: single, multi pulse, sinusoidal, space vector modulation techniques – VSR operation-Application to drive system – Current source inverters.

UNIT 5: MODERN INVERTERS	**9**

Multilevel concept – diode clamped – flying capacitor – cascaded type multilevel inverters - Comparison of multilevel inverters - application of multilevel inverters – PWM techniques for MLI – Single phase &Three phase Impedance source inverters - Filters

TOTAL: 45 PERIODS

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

CO1 Ability to acquire and apply knowledge of mathematics in power converter analysis

CO2 Ability to model, analyze and understand power electronic systems and equipment

CO3 Ability to formulate, design and simulate phase controlled rectifiers for generic load

and for machine loads

CO4 Ability to formulate, design, simulate switched mode inverters for generic load and for machine loads

CO5 Ability for device selection and calculation of performance parameters of power converters under various operating modes

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2			
CO1	3	3	1	3		1							3	3			
CO2	3	3	3	2	2								3	3			
CO3	3	3	3	1	1								3	3			
CO4	3	1	1	1	3		1				3		3	3			
CO5	3	1	1	1	2	1							3	3			

TEXT BOOKS:

1. Rashid M.H., “Power Electronics Circuits, Devices and Applications ", Prentice Hall India, fourth Edition, New Delhi, 2014.

2. Jai P. Agrawal, “Power Electronics Systems”, Pearson Education, Second Edition, 2002.

3. Bimal.K.Bose “Modern Power Electronics and AC Drives”, Pearson Education, Second Edition, 2003.

4. Ned Mohan, T.M.Undeland and W.P.Robbins, “Power Electronics: converters, Application and design” John Wiley and sons. Wiley India edition, 2006.

5. Philip T. krein, “Elements of Power Electronics” Oxford University Press-1998

REFERENCE BOOKS:

1. P.C.Sen, “Modern Power Electronics”, Wheeler Publishing Co, First Edition, New Delhi, 1998.

2. P.S.Bimbhra, “Power Electronics”, Khanna Publishers, Eleventh Edition, 2003.

3. Bin Wu, Mehdi Narimani, "High-power Converters and AC Drives", Wiley, 2nd Edition,

WEB RESOURCES:

1. VSR operation
https://www.researchgate.net/figure/Four-modes-of-operation-of-the-VSR-a-PWM-self-

commutated-rectifier-b-Rrectifier_fig16_3218408
2. Multilevel inverter https://www.elprocus.com/multilevel-inverter-types-advantages/

EE606210- MODERN RECTIFIERS AND RESONANT CONVERTERS					
Course Category: Professional Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**
COURSE OBJECTIVES:					

- To understand the harmonics standards
- To analyse and design power factor correction rectifiers for UPS applications.
- To analyse and design resonant converters for SMPS applications.
- To carry out of dynamic analysis of DC to DC Converters.
- To introduce the control techniques for control of resonant converters.

UNIT 1: POWER SYSTEM HARMONICS & LINE COMMUTATED RECTIFIERS	**9**

Average power-RMS value of a waveform-Power factor-AC line current harmonic standards IEC 1000-IEEE 519- The Single phase full wave rectifier-Continuous Conduction Mode- Discontinuous Conduction Mode - Three phase rectifiers- Continuous Conduction Mode-Discontinuous Conduction Mode- Harmonic trap filters.

UNIT 2: PULSE WIDTH MODULATED RECTIFIERS	**9**

Properties of Ideal rectifiers-Realization of non-ideal rectifier-Control of current waveform- Average current control-Current programmed Control- Hysteresis control-Nonlinear carrier control-Single phase converter system incorporating ideal rectifiers-Modelling losses and efficiency in CCM high quality rectifiers- solution for converter Efficiency η.

UNIT 3: RESONANT CONVERTERS	**9**

Review on Parallel and Series Resonant Switches-Soft Switching- Zero Current Switching – Zero Voltage Switching -Classification of Quasi resonant switches-Zero Current Switching of Quasi Resonant Buck converter, Zero Current Switching of Quasi Resonant Boost converter, Zero Voltage Switching of Quasi Resonant Buck converter, Zero Voltage Switching of Quasi Resonant Boost converter: Steady State analysis.

UNIT 4: DYNAMIC ANALYSIS OF SWITCHING CONVERTERS	9

Review of linear system analysis-State Space Averaging-Basic State Space Average Model- State Space Averaged model for Buck Converter, Boost Converter, Buck Boost Converter and Cuk Converter.

UNIT 5: CONTROL OF RESONANT CONVERTERS	9

Pulse Width Modulation-Voltage Mode PWM Scheme-Current Mode PWM Scheme-Design of Controllers: PI Controller, Variable Structure Controller, Optimal Controller for the source current shaping of PWM rectifiers.

TOTAL: 45 PERIODS

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

CO1: Ability to acquire and apply knowledge of mathematics in power converter analysis and understanding of harmonic standards

CO2: Ability to analyze and understand power electronic systems and equipment

CO3: Ability to analyze, design and simulate resonant converters for low power applications

CO4: Ability to develop mathematical model of switching converters to carry out dynamic analysis

CO5: Ability to design and implement different controllers and switching schemes for the control of converters

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2		
CO1	2	1		2	3		1	1		2		2	1	2		
CO2	2	1		1	3		1	1		2		2	1	2		
CO3	2	2		2	3		1	1		2		2	1	2		
CO4	2	2		2	3		1	1		2		2	1	2		
CO5	2	2		2	3		2	2		2		2	1	2		

TEXT BOOKS:

1. Robert W. Erickson &Dragon Maksimovic "Fundamentals of Power Electronics" Second Edition, 2001.

Ned Mohan, "Power Electronics: A first course", John Wiley,2012

REFERENCE BOOKS:

1.John G. Kassakian, Martin F. Schlecht, George C. Verghese, “Principles of Power Electronics”, Pearson, India, New Delhi, 2010.

2. Simon Ang and Alejandra Oliva, “Power Switching Converter”, Yesdee publishers, New Delhi, 2nd edition (first Indian Reprint), 2010.

WEB RESOURCES:

1.Zero current switching
https://www.sciencedirect.com/topics/engineering/zero-current-switching

2. Variable Structure Controller
file:///C:/Users/user/Downloads/Variable_Structure_Control_and_Applications.pdf

STREAM 3 – EMBEDDED SYSTEMS

EE606301-ARM PROCESSORS AND CONTROLLERS					
Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

To provide an exposure to the students on microcontrollers, their architecture and choose appropriate microcontroller for a real time application and to impart a thorough understanding about the programming techniques.

UNIT 1: PIC MICROCONTROLLER – ARCHITECTURE **9**

PIC Architecture- RISC Architecture-Program Memory Organization- Branch, Call and Time Delay Loop-PIC I/O Port Programming-AL Instructions and Programs-PIC Bank Switching, Table Processing, Macros and Modules-PIC Configuration Registers-PIC Hardware Connection-ROM Loaders.

UNIT 2 : **PIC INTERFACING** **9**

Timer Programming Timers 0 and 1-Programming Timers 2 and 3-Serial Port Programming-Interrupt Programming -Erasing and Writing to Flash-Reading and Writing Data to EEPROM-Standard and Enhanced CCP Modules-Compare Mode Programming Capture Mode Programming-PWM Programming- ECCP Programming.

UNIT 3: ARM ARCHITECTURE **9**

ARM7TDMI Programmers Model-Processor Modes-Program Status Registers-Vector Table-Assembler Rules and Directives-Predefined Register Names-Macros-Assembler

Operators-Literals-Load and Store Instructions Operand Addressing-Endianness-ARM rotation Scheme-Loading Constants and Addresses into Registers.

UNIT 4: ARM PROGRAMMING **9**

Data processing operations-Loops and Branches-LUT-Jump tables-Binary Searches - LDM/STM Instruction Full/Empty Ascending/Descending Stacks-Subroutines-Passing Parameters: In Registers, By Reference, On The Stack-ARM APCS-Exception Handling-Memory Mapped Peripherals-LPC2104-LPC 2132-Thumb Instruction Set-Thumb Programmers Model-Thumb Branch Instructions- Thumb Data Processing instructions-Thumb single register data transfer- Thumb multiple register data transfer instructions Thumb implementation.

UNIT 5:EMBEDDED APPLICATIONS **9**

ADC, DAC and sensor interfacing –LCD and Keyboard Interfacing -calculator with keypad –Relays and Opt isolators-Stepper Motor Interfacing-DC Motor Interfacing - PWM motor control with CCP-DC Motor Control with ECCP

TOTAL: 45 PERIODS

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

CO1: Learn to develop the hardware for embedded system application based on the processors.

CO2: Incorporate suitable microcontroller along with appropriate interfacing circuits and implement the same for an application with software programs

CO3: Explore the features of the microcontrollers and provide apt solutions for any embedded application.

CO4: Develop the hardware for embedded system application based ARM programming.

CO5: Design embedded models for different applications

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2		2	1	1	2	2	2	2	2	
CO2	2	3	3	2	1	2	1	1	2	1	2	1	2	1
CO3	3	2	2	3	1	2	2	2	2	2	2		3	1
CO4	2	2	2	3		2	1	2	1	1	1	2	3	
CO5	3	2	2	3	1	2	1	2	1	1	1	3	3	1

TEXT BOOKS:

1. Muhammad Ali Mazidi, "PIC Microcontrollers and Embedded Systems Using Assembly

and C for PIC18", Pearson Education, 2016
2. William Hohl, "ARM Assembly Language", CRC Press, Second Edition, 2015.
3. ARM Architecture Reference manual, ARM Limited, 2014.
REFERENCE BOOKS:
1.Steve Furber,"ARM System-on-Chip Architecture", Addison-Wesley Professional; ll edition 2018
2. John B. Peatman, "Design with PIC microcontrollers", Pearson Education, Singapore - 2018.
3.Andrew Sloss, Dominic Symes, and Chris Wright, "ARM System Developer's Guide Designing and Optimizing System", the Morgan Kaufmann Series, 2014
WEB RESOURCES:
1.Embedded applications https://www.digi.com/blog/post/examples-of-embedded-systems
2.ARM ARCHITECTURE https://www.sciencedirect.com/journal/journal-of-systems-architecture

EE606302-EMBEDDED COMPUTING SYSTEM DESIGN					
Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**
COURSE OBJECTIVES:					

- To introduce the fundamentals of microcontroller based system design
- To teach I/O and RTOS role on microcontroller
- To know Microcontroller based system design, applications.
- To teach I/O interface in system Design
- To involve Discussions/ Practice/Exercise onto revising & familiarizing the concepts acquired over the 5Units of the subject for improved employability skills

UNIT 1: 8051 ARCHITECTURE	**9**
Architecture – memory organization – addressing modes – instruction set – Timers - Interrupts - I/O ports, Interfacing I/O Devices – Serial Communication.	

UNIT 2: 8051 PROGRAMMING	**9**
Assembly language programming – Arithmetic Instructions – Logical Instructions –Single bit Instructions – Timer Counter Programming – Serial Communication Programming, Interrupt Programming, LCD digital clock, thermometer – Significance of RTOS for 8051.	
UNIT 3: PIC MICROCONTROLLER	**9**
Architecture – memory organization – addressing modes – instruction set – PIC programming in Assembly & C –I/O port, Data Conversion, RAM & ROM Allocation, Timer programming, practice in MP-LAB.	
UNIT 4: PERIPHERAL OF PIC MICROCONTROLLER	**9**
Timers – Interrupts, I/O ports- I2C bus-A/D converter-UART- CCP modules -ADC, DAC and Sensor Interfacing –Flash and EEPROM memories.	
UNIT 5: SYSTEM DESIGN – CASE STUDY	**9**
Interfacing LCD Display – Keypad Interfacing - Generation of Gate signals for converters and Inverters - Motor Control – Controlling DC/ AC appliances – Measurement of frequency – Stand alone Data Acquisition System.	
TOTAL: 45 PERIODS	
COURSE OUTCOMES: At the end of the course, the student will be able to	
CO1: Learn assembly and C-programming of PIC.	
CO2: Learn Interfacing of Microcontroller.	
CO3: Study about PIC microcontroller and system design.	
CO4: Enrich their knowledge with hands-on experiments and project based learning.	
CO5: Utilize microcontroller software development tools such as a compiler, make files, or compile scripts.	

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	2	2	1	2	2	1	2			2	2	1
CO2	2	1	2	2	2	2	2	1	2	1	2	2	2	1
CO3	1	2	2	2	2	2		1	2	1	2	2		1
CO4	2	1	2	1	1	2	2		2	1	2	1	2	
CO5	2	2	2	2	1	2		2	2	1	2	1		2

TEXT BOOKS:

1. Causey, D., Mazidi, M. A., McKinlay, R. PIC Microcontroller and Embedded Systems: Using Assembly and C for PIC18. , Micro DigitalEd, 2016.

2. Muhammad Ali Mazidi, Sarmad Naimi, Sepehr Naimi, AVR Microcontroller and

Embedded Systems using Assembly and C, Pearson Education 2014
3. Rajkamal,"Microcontrollers Architecture, Programming Interfacing, & System Design, Pearson, 2012.
REFERENCE BOOKS:
1. Senthil Kumar, Saravanan, Jeevanathan, Microprocessor & Microcontrollers, Oxford, 2013
2. Muhammad Ali Mazidi, Janice G. Mazidi and Rolin D. McKinlay, 'The 8051 Microcontroller and Embedded Systems Using Assembly and C' , 2nd edition, 2012
3. MykePredko, "Programming and customizing the 8051 Microcontroller", Tata McGraw Hill 2008.
WEB RESOURCES:
1.Microprocessors And Microcontrollers swayam.gov.in/nd1_noc20_ee42/preview
2.PIC Microcontroller pic-microcontroller.com/online-courses-learn-pic

EE606303-REAL TIME OPERATING SYSTEMS					
Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**
COURSE OBJECTIVES:					
• To review the fundamentals of basic operating systems and its implementation • To review the fundamentals of real time operating systems and its implementation • To impart knowledge on programming real time scheduling and interrupt processing • To compare the types and functionalities in commercial OS, application development using RTOS • To introduce the basics involved in Linux supported RTOS application and android user interface					
UNIT 1: REVIEW OF OPERATING SYSTEMS					**9**

Basic Principles - Operating System structures – System Calls – Files – Processes – Design and Implementation of processes – Communication between processes – Introduction to Distributed operating system – issues in distributed system: states, events, clocks- Distributed scheduling-Fault & recovery.	
UNIT 2: OVERVIEW OF RTOS	**9**
RTOS Task and Task state –Multithreaded Preemptive scheduler- Process Synchronization- Message queues– Mailboxes -pipes – Critical section – Semaphores – Classical synchronization problem – Deadlocks	
UNIT 3: REAL TIME MODELS AND LANGUAGES	**9**
Event Based – Process Based and Graph based Models – Real Time Languages – RTOS Tasks –RT scheduling - Interrupt processing – Synchronization – Control Blocks – Memory Requirements.	
UNIT 4: REAL TIME KERNEL	**9**
Principles – Design issues – RTOS Porting to a Target – Comparison and Basic study of various RTOS like – VX works – Linux supportive RTOS – C Executive	
UNIT 5: INTRODUCTION TO EMBEDDED OS	**9**
Discussions on Basics of Linux supportive RTOS – uCOS-C Executive for development of RTOS Application –introduction to Android Environment -The Stack – Android User Interface – Preferences, the File System, the Options Menu and Intents, with one Case study	
TOTAL: 45 PERIODS	
COURSE OUTCOMES: At the end of the course, the student will be able to	
CO1: Assimilate the ideas of real-time scheduling and analysis, including clock-driven and priority driven scheduling.	
CO2: Analyse the theoretical background (specification/verification) and practical knowledge of real-time operating systems.	
CO3: Appreciate the use of multitasking techniques in real time systems.	

CO4: Design and implement the real-time operating systems.

CO5: Apply the attained knowledge in Android Environment

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	1	2	3					2	1	2	1	1
CO2	2	1	1	1	3							2	1	1
CO3	2	2	2	2	3							2	1	1
CO4	2	2	2	2	3	2			2			2	1	1
CO5	2	2	2	2	3	2	2	2	2	2	1	2	2	2

TEXT BOOKS:

1. C.M.Krishna, Kang.G.Shin, Real Time Systems. India: McGraw-Hill Education (India) Pvt Limited, 2010.

2. Raj Kamal, Embedded Systems, Architecture, Programming and Design, Tata McGraw Hill, 2016.

3. Abraham Silberschatz, Peter B. Galvin, Greg Gagne, Operating System Concepts, 10th edition, Wiley 2018.

REFERENCE BOOKS:

1. Marko Gargenta, “Learning Android “, O’reilly, 2011.

2. CorbetRubini, Kroah-Hartman, “Linux Device Drivers”, O’reilly, 2016.

3. Charles Crowley, “Operating Systems-A Design Oriented approach” McGraw Hill, 2017.

WEB RESOURCES:

1.Linux supportive RTOS

https://tldp.org/LDP/LG/issue96/bhargava.html

2.Introduction to Android Environment

https://egyankosh.ac.in/bitstream/123456789/76218/1/Unit-4.pdf

Course Category: Program Elective	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To provide a clear understanding on the basic concepts, Building Blocks of Embedded System
- To teach the fundamentals of Embedded processor Modelling, Bus Communication in Processors, Input/output interfacing
- To introduce on processor scheduling algorithms, Basics of Real time operating system
- To discuss on aspects required in developing a new embedded processor, different Phases & Modelling of embedded system
- To involve Discussions/ Practice/Exercise onto revising & familiarizing the concepts acquired over the 5 Units of the subject for improved employability skills.

UNIT 1: INTRODUCTION TO EMBEDDED SYSTEMS	**9**

Introduction to Embedded Systems –Structural units in Embedded processor, selection of processor & memory devices- DMA, Memory management methods- memory mapping, cache replacement concept, Timer and Counting devices, Watchdog Timer, Real Time Clock

UNIT 2: EMBEDDED NETWORKING AND INTERRUPTS SERVICE MECHANISM	**9**

Embedded Networking: Introduction, I/O Device Ports & Buses– Serial Bus communication protocols -RS232 standard – RS485 –USB – Inter Integrated Circuits (I2C) – interrupt sources , Programmed-I/O busy-wait approach without interrupt service mechanism- ISR concept-– multiple interrupts – context and periods for context switching, interrupt latency and deadline -Introduction to Basic Concept Device Drivers.

UNIT 3: RTOS BASED EMBEDDED SYSTEM DESIGN	**9**

Introduction to basic concepts of RTOS- Task, process & threads, interrupt routines in RTOS, Multiprocessing and Multitasking, Preemptive and non preemptive scheduling, Task communication shared memory, message passing-, Interprocess Communication – synchronization between processes-semaphores, Mailbox, pipes, priority inversion, priority inheritance comparison of commercial RTOS features - RTOS Lite, Full RTOS, VxWorks, µC/OS-II, RT Linux.

UNIT 4: SOFTWARE DEVELOPMENT TOOLS	**9**

Software Development environment-IDE, assembler, compiler, linker, simulator, debugger, In Circuit emulator, Target Hardware Debugging, need for Hardware-Software Partitioning and Co-Design. Overview of UML, Scope of UML modelling, Conceptual model of UML, Architectural, UML basic elements Diagram- Modelling techniques - structural, Behavioural, Activity Diagrams.

UNIT 5: EMBEDDED SYSTEM APPLICATION DEVELOPMENT **9**

Objectives, different Phases &Modelling of the Embedded product Development Life Cycle (EDLC), Case studies on Smart card- Adaptive Cruise control in a Car -Mobile Phone software for key inputs.

TOTAL:45 PERIODS

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

CO1: Design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

CO2: Describe the differences between the general computing system and the embedded system, also recognize the classification of embedded systems

CO3: Design real time embedded systems using the concepts of RTOS.

CO4: Foster ability to understand the role of embedded systems in industry.

CO5: Design embedded applications for different applications.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	
CO1	3	2	3	1	1	-	2	2	2	2	1	3	1	2	2
CO2	2	3	2	2	2	1				2	2	2	2	2	2
CO3	2	2	3	3	3	2						2		1	-
CO4	2	3	3	2	3			-	2			2			
CO5	2	3	3	2	3			1	2	1	3	2		1	

TEXT BOOKS:

1. Rajkamal, ‘Embedded system-Architecture, Programming, Design’, TMH, 2011.

2. Lyla B Das,” Embedded Systems-An Integrated Approach”, Pearson, 2013.

3. Peckol, “Embedded system Design”, JohnWiley & Sons, 2010

REFERENCE BOOKS:

1.Elicia White, ”Making Embedded Systems”, O’Reilly Series, SPD,2011

2. Simon Monk, “Make: Action, Movement, Light and Sound with Arduino and Raspberry Pi”, O’Reilly Series, SPD, 2016.

3. Bruce Powel Douglass, ”Real-Time UML Workshop for Embedded Systems, Elsevier, 2011.

WEB RESOURCES:

1.Embedded System design

tps://www.classcentral.com/course/swayam-embedded-systemsdesign-7943

2.Online Courses for Embedded system

https://openlabpro.com/online-courses/

EE606305-SOFTWARE FOR EMBEDDED SYSTEMS					
Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To expose the students to the fundamentals of embedded Programming
- To Introduce the GNU C Programming Tool chain in Linux.
- To study basic concepts of embedded C , Embedded OS &Python Programming
- To introduce time driven architecture, Serial Interface with a case study
- To involve Discussions/ Practice/Exercise onto revising & familiarizing the concepts acquired over the 5 Units of the subject for improved employability skills

UNIT 1: EMBEDDED PROGRAMMING **9**

C and Assembly - Programming Style - Declarations and Expressions - Arrays, Qualifiers and Reading Numbers - Decision and Control Statements - Programming Process - More Control Statements - Variable Scope and Functions - C Preprocessor - Advanced Types – Simple Pointers -Debugging and Optimization – In-line Assembly.

UNIT 2: C PROGRAMMING TOOL CHAIN IN LINUX **9**

C preprocessor - Stages of Compilation - Introduction to GCC - Debugging with GDB - The Make utility - GNU Configure and Build System - GNU Binary utilities - Profiling - using gprof - Memory Leak Detection with valgrind - Introduction to GNU C Library.

UNIT 3: EMBEDDED C **9**

Adding Structure to 'C' Code: Object oriented programming with C, Header files for Project and Port, Examples. Meeting Real-time constraints: Creating hardware delays - Need for timeout mechanism -Creating loop timeouts - Creating hardware timeouts.

UNIT 4: EMBEDDED OS **9**

Creating embedded operating system: Basis of a simple embedded OS, Introduction to sEOS, Using Timer 0 and Timer 1, Portability issue, Alternative system architecture, Important design considerations when using sEOS Memory requirements – embedding serial communication & scheduling data transmission - Case study: Intruder alarm system.

UNIT 5: PYTHON PROGRAMMING **9**

Basics of PYTHON Programming Syntax and Style – Python Objects– Dictionaries – comparison with C programming on Conditionals and Loops – Files – Input and Output – Errors and Exceptions –Functions – Modules – Classes and OOP – Execution Environment..

TOTAL: 45 PERIODS

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

CO1: Use GNU C to develop embedded software.

CO2: Understand the fundamental embedded systems design paradigms, architectures, possibilities and challenges, both with respect to software and hardware.

CO3: Improved Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in embedded systems design.

CO4: Understand the concepts of operating systems to design embedded systems.

CO5: Understand embedded programming using python.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	2	1	1	1	2	1	1		2	2		1
CO2	3	2	2	2	2						2	1	2	2
CO3	3	2	3	3	1						2	1	3	1
CO4	3	2	3	3	3						2	1	1	
CO5	3	3	3	3	3	2		1	1		2	1		

TEXT BOOKS:

1Mark J.Guzdial," introduction to computing and programming in python – a Multimedia approach, 4th edition, Pearson Education, 2015.

2. Wesley J.Chun, "Core python application Programming 3rd Edition", Pearson Educat, 2016.

3. Michael J Pont, “Embedded C”, Pearson Education, 2007
REFERENCE BOOKS:
1. Mark Lutz, Learning Python, Powerful OOPs, O’reilly, 2011.
2. Dr.Bandu Meshram, Object Oriented Paradigm C++ Beginners Guide C&C++, SPD, 2016.
3. Peter Prinzs, Tony Crawford, C in a Nutshell, O’Reilly, 2016.
WEB RESOURCES:
1.Embedded Systems Design https://swayam.gov.in/nd1_noc20_cs14/preview
2.Introduction to Embedded Systems Software and Development Environments https://www.coursera.org/learn/introduction-embedded-systems

EE606306-EMBEDDED LINUX					
Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**
COURSE OBJECTIVES:					
• To study the fundamentals of Linux Operating system, its basic commands and shell programming • To learn the history of embedded Linux, various distributions and basics of GNU Cross Platform Tool Chain • To study on different Host-Target setup, debug and various memory device, file systems and performance tuning • To learn the concept of configuring kernel using the cross-platform tool chain					
UNIT 1: FUNDAMENTALS OF LINUX					**9**
Overview – classical Encryption Techniques – Block Ciphers and the Data Encryption standard – Introduction to Finite Fields – Advanced Encryption standard – Contemporary, Symmetric Ciphers – Confidentiality using Symmetric Encryption. Basic Linux System Concepts: Working with Files and Directories -Introduction to Linux File system -Working with Partitions and File systems -Understanding Linux Permissions; Using Command Line					

Tools: Executing Commands from the Command Line - Getting to a Shell - Popular Command- Line Commands - Working with the Bash Shell.	
UNIT 2:VARIOUS DISTRIBUTIONS AND CROSS PLATFORM TOOL CHAIN	**9**
Introduction - History of Embedded Linux - Embedded Linux versus Desktop Linux – Commercial Embedded Linux Distribution - Choosing a distribution -Embedded Linux Distributions – Architecture of Embedded Linux – Linux Kernel Architecture - Porting Roadmap - GNU Cross Platform Tool chain.	
UNIT 3:HOST-TARGET SETUP AND OVERALL ARCHITECTURE	**9**
Real Life Embedded Linux Systems - Design and Implementation Methodology - Types of Host / Target Development Setups - Types of Host / Target Debug Setups - Generic Architecture of an Embedded Linux System - System Startup - Types of Boot Configurations - System Memory Layout – Processor Architectures - Buses and Interfaces - I/O – Storage.	
UNIT 4:KERNEL CONFIGURATION	**9**
A Practical Project Workspace - GNU Cross-Platform Development Tool chain -Library Alternatives- Other Programming Languages - Eclipse: An Integrated Development Environment – Terminal Emulators - Selecting a Kernel - Configuring the Kernel - Compiling the Kernel - Installing the Kernel - Basic Root File system Structure - Libraries - Kernel Modules and Kernel Images - Device Files – Main System Applications - System Initialization.	
UNIT 5:LINUX DRIVERS	**9**
Introduction in to basics on Linux drivers, introduction to GNU cross platform Tool chain- Case study on programming one serial driver for developing application using Linux Driver.	
	TOTAL: 45 PERIODS
COURSE OUTCOMES: At the end of the course, the student will be able to	
CO1: Use Linux desktop and GNU tool chain with Eclipse IDE.	
CO2: Cross compile Linux kernel and port it to target board	
CO3: Add applications and write customized application for the Linux kernel in the target board	
CO4: Study about distributions and cross platform tool chain.	

CO5: Enhance the employability and entrepreneurship capacity due to knowledge upgradation on recent trends in embedded systems design.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	1	1	1				3	1	3	1
CO2	2	2	2	2	2	2	2				2	2	2	2
CO3	2	2	2	2	2	2	2				2	2	2	2
CO4	3	3	1	2	1	1	1				3	1	2	2
CO5	2	3	2	3	1	1	1				3	1		

TEXT BOOKS:

1. Simmonds, Chris, Vasquez, Frank. Mastering Embedded Linux Programming: Create Fast and Reliable Embedded Solutions with Linux 5.4 and the Yocto Project 3.1 (Dunfell). United Kingdom: Packt Publishing, 2021.

2. Lad, Amol, Neelakandan, Sriram, Raghavan, P. Embedded Linux System Design and Development. United Kingdom: Auerbach Publishers, Incorporated, 2019.

3. Negus, Christopher, Clinton, David. Ubuntu Linux Bible. United Kingdom: Wiley, 2020.

REFERENCE BOOKS:

1 Madieu, John. Mastering Linux Device Driver Development: Write Custom Device Drivers to Support Computer Peripherals in Linux Operating Systems. United Kingdom: Packt Publishing, 2021.

2. Persson, Jack-Benny. Linux System Programming Techniques: Become a Proficient Linux System Programmer Using Expert Recipes and Techniques. N.P.: Packt Publishing, 2021.

3. Billimoria, Kaiwan N. Hands-On System Programming with Linux: Explore Linux System Programming Interfaces, Theory, and Practice. United Kingdom: Packt Publishing, 2018.

WEB RESOURCES:

1 - Linux Basics-I

https://nptel.ac.in/courses/117106113

2.Embedded Systems: Introduction

https://nptel.ac.in/courses/108102045

EE606307-EMBEDDED CONTROL SYSTEMS DESIGN					
Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To provide a clear understanding on the basic concept of embedded control system
- To impart the fundamentals of Real time operating system
- To study the software and hardware design interface, SPI, RTC interfacing and programming.
- To design and develop a software for embedded control applications and also learn about interfacing using C & C++
- To analyse the real time applications of embedded controller

UNIT 1: EMBEDDED SYSTEM ORGANIZATION	**9**

Embedded computing – characteristics of embedded computing applications – embedded system design challenges; Build process for Realtime Embedded system – Selection of processor; Memory; I/O devices-Rs- 485, MODEM, Bus Communication system using I2C, CAN, USB buses, 8 bit –ISA, EISA bus;

UNIT 2:REAL-TIME OPERATING SYSTEM	**9**

Introduction to RTOS; RTOS- Inter Process communication, Interrupt driven Input and Output -Non maskable interrupt, Software interrupt; Thread – Single, Multithread concept; Multitasking Semaphores.

UNIT 3:INTERFACE WITH COMMUNICATION PROTOCOL	**9**

Design methodologies and tools – design flows – designing hardware and software Interface. – system integration; SPI, High speed data acquisition and interface-SPI read/write protocol.

UNIT 4:RTC INTERFACING AND PROGRAMMING	**9**

Design of Software for Embedded Control Software abstraction using Mealy- Moore FSM controller - Layered software development -Basic concepts of developing device driver – SCI – Software - interfacing & porting using standard C & C++ ; Functional and performance Debugging with benchmarking Real-time system software – Survey on basics of contemporary RTOS – VX Works, UC/OS-II.

UNIT 5:CASE STUDIES WITH EMBEDDED CONTROLLER	**9**

Programmable interface with A/D & D/A interface; Digital voltmeter, control- Robot system; PWM motor speed controller, serial communication interface.

TOTAL: 45 PERIODS

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

CO1: Understand the basic concept of embedded system such as memory, I/O devices, and bus communication system.

CO2: Design real time embedded systems using the concepts of RTOS.

CO3: Explain and design of software for embedded control.

CO4: Implement the real-time operating system principle.

CO5: Design simple A/D and D/A interface circuits.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	2	2	2	2	2	2	2	2	2		
CO2	2	3	2	2	2	2					2	1	2	2
CO3	2	3	2	3	2	2							3	3
CO4	2	3	2	3	3	3							2	2
CO5	2	2	3	3	2	2	2						3	3

TEXT BOOKS:

1. Murti, KCS. Design Principles for Embedded Systems. Singapore: Springer Nature Singapore, 2021.

2. Lacamera, Daniele. Embedded Systems Architecture: Explore Architectural Concepts, Pragmatic Design Patterns, and Best Practices to Produce Robust Systems. India: Packt Publishing, 2018.

3. Berger, Arnold. Embedded Systems Design: An Introduction to Processes, Tools, and Techniques. United Kingdom: Taylor & Francis Group, 2017.

REFERENCE BOOKS:

1 Subero, Armstrong. Programming PIC Microcontrollers with XC8. United States: Apress, 2017.

2. Dean, Alexander G. Embedded Systems Fundamentals with Arm Cortex-M Based Microcontrollers: A Practical Approach Nucleo-F091RC Edition. N.P.: ARM Education Media, 2021.

WEB RESOURCES:

1 - Embedded System Design with ARM
https://nptel.ac.in/courses/106105193

2.Embedded Systems Design
https://nptel.ac.in/courses/106105159

EE606308-EMBEDDED CONTROL FOR ELECTRICAL DRIVES					
Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**
COURSE OBJECTIVES:					

- To learn the models, new innovations required Electro-Mechanical systems via a roadmap- driven development process as required by modern industries.
- To learn the embedded software development skills required for industrial drive systems
- To study how to develop an innovation attitude for the design, modelling, and development industrial drives systems.

UNIT 1: INTRODUCTION	**9**

Electrical Drives - driving forces and evolving technologies-advantages and application range of electric drives- energy savings through drive system - elements of drive system - drive characteristics -load dynamics and steady state stability - multiquadrant operation - electric motors for drives - power electronic converters for drives - Modern trends in industrial drives and control - Motor Control Sensors-Evaluation of microcontrollers for motor control- Selection of suitable control device for drives.

UNIT 2:DC MOTOR DRIVES	**9**

Introduction to DC-motor drives - speed control of DC motor drive with controlled rectifiers and choppers-speed control using inner current loop and outer speed loop - design of current loop with pole-zero cancellation - simulation of DC drives - Embedded controller based implementation of DC drives - converter structure - modes of operation - control variable algorithm - initialization of ADC/Timers/Interrupts - voltage/ current sensing and comparison - PWM signal generation – Case study.

UNIT 3:INDUCTION MOTOR DRIVES	**9**

Induction Motor Drives: Reference frame theory - transformation of variables from stationary to arbitrary reference frame - PWM inverter fed induction motor drives - Vector control - open loop and closed loop PWM control - sensor less IM drives : a study - direct torque and flux control -space vector PWM control. Embedded controller based speed control implementation for IM drives: system components - sensors - controllers - current/speed measurements - scaling operation - control algorithm of speed measurement during high-speed/low speed regions - development of closed loop control block - Case

study.

UNIT 4:SYNCHRONOUS MOTOR DRIVES **9**

Open loop VSI fed drive and its characteristics - Self control - Torque control - Torque angle control - Power factor control - Brush less excitation systems - Starting methods - Field oriented control - Design of closed loop operation of Synchronous motor drive systems. PM Synchronous Motor Drives: Types and torque developed in PMSM - Stationary and rotor reference frame modelling of PMSM - PMSM control system - Case study.

UNIT 5:SPECIAL MACHINES DRIVES **9**

Switched Reluctance Motor drive: Fundamentals and control of SRM drives - open loop and closed control-Closed loop torque and speed control - Implementation of speed control algorithm using TMS 320F28335 processor. Brush less DC Motor Drives: Principals of operation - torque generation - open loop and closed control of BLDC drive - Case study.

Stepper Motor Drives: Types and basic operation - stepper motor drive system - Implementation of control algorithm using MC68HC11E9 Microcontroller. Introduction FPGA based implementation for Electric Drive Systems.

TOTAL: 45 PERIODS

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

CO1: Understand the models, new innovations required Electro-Mechanical systems via a roadmap- driven development process as required by modern industries.

CO2: Improve the embedded software development skills required for industrial drive systems

CO3: Develop an innovation attitude for the design, modelling, and development industrial drives systems.

CO4: Improve the embedded software development skills required for controlling the synchronous motor drives

CO5: Improve the embedded software development skills required for controlling the BLDC motors

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	3							2		1
CO2	2	3	3	2	2		1			1		2	2	
CO3	2	3	2	3	2		2		2			2		1
CO4	2	2	2	3	3				2			2	2	2
CO5	2	3	3	2	2							2		1

TEXT BOOKS:

1Bose, Bimal K. Power Electronics and Motor Drives: Advances and Trends. Netherlands: Elsevier Science, 2020.

2. Nasar, Syed A., Boldea, Ion. Electric Drives. United States: CRC Press, 2016.

REFERENCE BOOKS:

1. Permanent Magnet Synchronous Machines. Switzerland: MDPI AG, 2019.

2. Handbook of Automotive Power Electronics and Motor Drives. United States: Taylor & Francis, 2017.

3. Gao, Yimin, Longo, Stefano, Ebrahimi, Kambiz, Ehsani, Mehrdad. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles. United States: CRC Press, 2018.

WEB RESOURCES:

1 Dc Motor Speed Control Controller Design

https://www.digimat.in/nptel/courses/video/108108077/L21.html

2.Embedded Systems

http://nitttrc.edu.in/nptel/courses/video/108105062/L36.html

EE606309-EMBEDDED SYSTEM FOR AUTOMOTIVE APPLICATIONS

Course Category: Program Elective	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To learn the fundamentals and building of Electronic Engine Control systems
- To study the functional components and circuits for vehicles
- To study the programmable controllers for vehicles
- To learn logics of automation & commercial techniques for vehicle communication

UNIT 1: BASICS OF ELECTRONIC ENGINE CONTROL SYSTEMS **9**

Motivation, concept for electronic engine controls and management- Standards; introduction to fuel economy- automobile sensors-volumetric, thermal, air-fuel ratio, solenoid, hall effect-exhaust gas oxygen sensors, Oxidizing catalytic efficiency, emission limits and vehicle performance; advantages of using Electronic engine controls – open and closed loop fuel control; Block diagram of Electronic ignition system and Architecture of a EMS with multi point fuel injection system, Direct injection; programmed ignition actuators interface to the ECU; starter motors and circuits - sensors interface to the ECU; Actuators and their characteristics – exhaust gas recirculation.

UNIT 2:FUEL CELL FOR AUTOMOTIVE POWER	9
Fuel cell-Introduction-Proton exchange membrane FC (PEM), Solid oxide fuel cell (SOFC)-properties of fuel cells for vehicles-power system of an automobile with fuel cell based drive, and their characteristics.	
UNIT 3:VEHICLE MANAGEMENT SYSTEMS	**9**
Electronic Engine Control-engine mapping, air/fuel ratio spark timing control strategy, fuel control, electronic ignition-Vehicle cruise control- speed controlant locking braking system-electronic suspension - electronic steering , wiper control ; Vehicle system schematic for interfacing with EMS,ECU. Energy Management system for electric vehicles- for sensors, accelerators, brake- Battery management, Electric Vehicles-Electrical loads, power management system-electrically assisted power steering system.	
UNIT 4:AUTOMOTIVE TELEMATICS	**9**
Role of Bluetooth, CAN, LIN and flex ray communication protocols in automotive applications; Multiplexed vehicle system architecture for signal and data / parameter exchange between EMS,ECUs with other vehicle system components and other control systems; Realizing bus interfaces for diagnostics, dashboard display ,multimedia electronics-Introduction to Society of Automotive Engineers(SAE). J1850 message with (IFR) in frame response in protocol-Local Interconnect n/w [LIN], Bluetooth.	
UNIT 5:ELECTRONIC DIAGNOSTICS FOR VEHICLES	**9**
System diagnostic standards and regulation requirements –On board diagnosis of vehicles electronic units & electric units-Speedometer, oil and temperature gauges, and audio system	
TOTAL: 45 PERIODS	
COURSE OUTCOMES: At the end of the course, the student will be able to	
CO1: Design and develop automotive embedded systems.	
CO2: Analyse various embedded products used in the automotive industry.	
CO3: Evaluate the opportunities involving technology, a product or a service required for developing a startup idea used for automotive applications.	
CO4: Understand the diagnostics techniques for electric vehicles.	
CO5: Understand the diagnostics standards for electric vehicles.	

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	3	2	2	3							1	
CO2	2	3	3	3	2	2			1			3	2	
CO3	2	2	3	3	2	2		3	2			3		1

CO4	3	2	2	2	2	2					1	2	3	2
CO5	2	3	2	3	2	3				1	2			

TEXT BOOKS:

1. Denton, Tom. Automobile Electrical and Electronic Systems. United Kingdom: CRC Press, 2017.

2. Zaman, Najamuz. Automotive Electronics Design Fundamentals. Germany: Springer International Publishing, 2015.

3. Abudbaker, S, Mahroogi, Faisal O., Alammari, Youssef, Sakthivel, R., Kaisan, M. U.., Narayan, S. Introduction to Automotive Engineering. United States: Wiley, 2019.

REFERENCE BOOKS:

1. Intelligent Vehicles: Enabling Technologies and Future Developments. Netherlands: Elsevier Science, 2017.

2. VanGelder, Kirk T. Automotive Electricity and Electronics. United States: Jones & Bartlett Learning, 2017.

3. Handbook of Automotive Power Electronics and Motor Drives. United States: Taylor & Francis, 2017.

WEB RESOURCES:

1 - Introduction to Automotive Embedded Systems & Autosar
https://www.youtube.com/watch?v=pHCBOLidXOY

2.Embedded Systems Basics
https://nptel.ac.in/courses/117106112

EE606310-EMBEDDED PRODUCT DEVELOPMENT

Course Category: Program Elective	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To study the basic concepts of product design, product features and its architecture
- To learn the possible approaches for product development
- To understand the concepts of industrial design strategies
- To study the stages of electronic product development
- To study about the embedded product design

UNIT 1: CONCEPTS OF PRODUCT DEVELOPMENT **9**

Need for PD- Generic product Development Process Phases- Product Development Process Flows- Product Development organization structures- Strategic importance of Product Planning process – Product Specifications- Target Specifications-Plan and establish product specifications - integration of customer, designer, material supplier and process planner, Competitor and customer – Understanding customer and behaviour analysis.	
UNIT 2:INTRODUCTION TO APPROACHES IN PRODUCT DEVELOPMENT	**9**
Product development management - establishing the architecture - creation - Product Architecture changes - variety – component standardization , clustering -geometric layout development - Fundamental and incidental interactions - related system level design issues - secondary systems - architecture of the chunks - creating detailed interface specifications	
UNIT 3:INDUSTRIAL DESIGN STRATEGIES	**9**
Role of Integrating CAE, CAD, CAM tools for Simulating product performance and manufacturing processes electronically- Basics on reverse engineering – Reverse engineering strategies – Finding reusable software components – Recycling real-time embedded software based approach and its logical basics- Incorporating reverse engineering for consumer product development –case study on DeskJet Printer	
UNIT 4:ELECTRONIC PRODUCT DEVELOPMENT STAGES	**9**
Product Development Stages-Embedded product modeling- Linear, Iterative, Prototyping, Spiral - Selection of Sensor, Voltage Supply, Power supply protection, Grounding and noise elimination methods, Thermal protection with heat management – PCB design steps – Software design and testing method – documentation.	
UNIT 5:EMBEDDED PRODUCTS DESIGN	**9**
Creating general Embedded System Architecture (with Case study example: Mobile Phone / DeskJet Printer./ Robonoid as a product) –Architectural Structures- Criteria in selection of Hardware Software Components, processors, input/output interfaces & connectors, ADC System, Memory, choosing Bus Communication Standards, Criteria in selection of Embedded OS/Device Drivers	
TOTAL: 45 PERIODS	
COURSE OUTCOMES: At the end of the course, the student will be able to	
CO1: Understand the integration of customer requirements in product design	
CO2: Apply structural approach to concept generation, creativity, selection and testing.	

CO3: Understand the various aspects of industrial design

CO4: Understand various aspects of its Reverse Engineering manufacture, economic analysis.

CO5: Design the consumer specific product and product architecture.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	3	2	2	2				3	1		
CO2	2	3	3	2	2	3							2	2
CO3	2	2	3	3	2	3							2	1
CO4	3	3	2	2	2	2							3	1
CO5	2	3	2	3	2	2	2			2	2	1		

TEXT BOOKS:

1. Ulrich, Karl. Product Design and Development. United States: McGraw-Hill Education, 2020.

2. Serksnis, Tony. Designing Electronic Product Enclosures. Germany: Springer International Publishing, 2018.

3. Advances in Engineering Design: Select Proceedings of FLAME 2018. Germany: Springer Singapore, 2019.

4 Aslett, Robert J., Acken, John M., Yerramilli, Siva K. Perspective On Holistic Engineering Management, A: Learning, Adapting And Creating Value. Singapore: World Scientific Publishing Company, 2021.

REFERENCE BOOKS:

1 Lacamera, Daniele. Embedded Systems Architecture: Explore Architectural Concepts, Pragmatic Design Patterns, and Best Practices to Produce Robust Systems. India: Packt Publishing, 2018.

2. Introduction to Product Design and Development for Engineers. United States: CRC Press, 2018.

3. Barlow, D. Neal, Post, Martiqua L.., Brandt, Steven A. Introduction to Engineering: A Project-based Experience in Engineering Methods. Germany: American Institute of Aeronautics and Astronautics, Incorporated, 2017.

WEB RESOURCES:

1 - Introduction Embedded System Design

https://www.digimat.in/nptel/courses/video/106105159/L01.html

2.Configure Management Elements

http://www.digimat.in/nptel/courses/video/117106112/L33.html

STREAM 4 – CONTROL AND INTRUMENTATION

EE606401- SENSORS AND TRANSDUCERS

Course Category: Program Elective	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To outline the concepts of all transducer types and to analyze their characteristics based on the industrial process requirements
- To explain the working principle of Resistive, Inductive, Capacitive and miscellaneous transducers.

UNIT 1: MEASUREMENTS AND INSTRUMENTATION OF TRANSDUCERS — **9**

Measurements – Basic method of measurement - Generalized scheme for measurement systems - Units andstandards - Errors – Classification of errors - Error analysis – Statistical methods - Sensor – Transducer -Classification of transducers - Basic requirement of transducers.

UNIT 2: CHARACTERISTICS OF TRANSDUCERS — **9**

Static characteristics and Dynamic characteristics, Mathematical model of transducers – Zero order - First order -Second Order , Response of transducers to standard input signals – Impulse, step , ramp and sinusoidal input.

UNIT 3: RESISTIVE TRANSDUCERS — **9**

Principle of operation, construction details, characteristics and application of Potentiometer, Strain gauge, LoadCell, Resistance thermometer, Thermistor and Hot wire anemometer.

UNIT 4: INDUCTIVE AND CAPACITIVE TRANSDUCER	9

Self-inductive transducer - Mutual inductive transducers - Linear Variable Differential Transformer – LVDT Accelerometer – RVDT - Synchros – Microsyn - Capacitive transducer – Variable Area Type - Variable Air Gaptype – Variable Permittivity type - Capacitor microphone.

UNIT 5: MISCELLEANEOUS TRANSDUCERS	9

Piezoelectric transducer, Hall Effect transducers, Thermocouple, Smart sensors , Fiber optic sensors , IC sensors- MEMS – Nano sensors - Digital transducers , Biosensors, Aerospace sensors and chemical sensors.

TOTAL: 45 PERIODS

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

CO1: Understand the concept of measurement system and analyse the error.

CO2: Analyse the characteristics of transducer with various forcing functions.

CO3: Apply the resistance transducers in various non-electrical parameter measurement.

CO4: Understand the working principles of inductive and capacitive transducers.

CO5: Understand the working principles of miscellaneous transducers those involved in different applications.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	2	-	-	-	-	-	-	-	3	3
CO2	3	3	3	2	3	-	-	-	-	-	-	-	3	3
CO3	3	3	3	2	2	-	-	-	-	-	-	-	2	3
CO4	3	3	3	3	3	-	-	-	-	-	-	-	3	2
CO5	3	3	3	3	3	-	-	-	-	-	-	-	3	3

TEXT BOOKS:

1. Doebelin, E.O. and Manik, D.N., "Measurement systems Application and Design", 6th McGraw-Hill Education Pvt. Ltd, 2011.

2. Sawhney. A.K, "A Course in Electrical and Electronics Measurements and Instrumentation", 18th Edition, Dhanpat Rai & Company Private Limited, 2007

REFERENCE BOOKS:

1. Patranabis, "Sensors and Transducers", 2nd edition, Prentice Hall of India Pvt. Ltd., 2003

2. D.V.S Murthy, Transducers and Instrumentation", Prentice Hall of India, second edition2010.

WEB RESOURCES:

1. Sensors and Actuators intro. https://archive.nptel.ac.in/courses/108/108/108108147/

2. Industrial Instrumentation. https://archive.nptel.ac.in/courses/108/105/108105064/

EE606402- INDUSTRIAL INSTRUMENTATION

Course Category: Program Elective	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- Enable the student to interpret the various types of non-electrical parameter measurement.

UNIT 1: MEASUREMENT OF FORCE, TORQUE AND SPEED — **9**

Force measurement – Hydraulic loadcell – Pneumatic load cell – Strain gauge load cell – Magneto elastic load cell – Piezoelectric load cell - Torque measurement – Strain gauge torsion meter - Relative regular twist method – Optical torsion meter – Electrical torsion meter – Speed measurement – Revolution counter – Capacitive tachometer - Drag cup type tachometer – D.C and A.C tacho generators – Magnetic pickup – Photoelectric pickup – Stroboscope.

UNIT 2: MEASUREMENT OF ACCELERATION, VIBRATION AND — **9**

DENSITY	
Accelerometers – LVDT, piezoelectric, strain gauge and variable reluctance type accelerometers – Mechanical Type vibration instruments – Seismic instrument as an accelerometer and vibrometer – Calibration of vibration pick-ups – Units of density and specific gravity used in industries – Baume scale, API scale – Pressure head type densitometer – Float type densitometer – Ultrasonic densitometer – Bridge type gas densitometer.	
UNIT 3: MEASUREMENT OF PRESSURE AND TEMPERATURE	**9**
Pressure measurement: Manometer-Elastic type pressure transducers - McLeod gauge - Thermal conductivity gauge - Ionization gauge - Dead weight tester - Temperature measurement: RTD - Two lead, three lead, four lead wire RTDs - Thermistors – Thermocouple - thermoelectric laws, types and cold junction compensation - Bimetallic thermometer – Pyrometer - Total radiation pyrometer, Optical pyrometer.	
UNIT 4: MEASUREMENT OF LEVEL AND FLOW	**9**
Level measurement: Float, Displacer type, Bubbler system, Resistance, Capacitance type - Flow measurement: Variable Head flowmeter - Orifice, Venturi tube, Flow nozzle, Dall tube, Pitot tube – Variable area flowmeter – Rotameter – Velocity measurement type flow meter – Hotwire anemometer – Positive displacement type flowmeter – Nutating disc type flowmeter - Turbine flowmeter - Electro Magnetic flow meter - Mass flow meter - Thermal, Coriolis type - Vortex shedding - Target flowmeter.	
UNIT 5: MEASUREMENT OF VISCOSITY AND HUMIDITY	**9**
Viscosity - Units - Terminologies – Capillary tube viscometer – Ostwald viscometer – Efflux viscometer: - Say bolt viscometer – Redwood viscometer – Engler viscometer - Rotameter type viscometer – Humidity terms – Sling psychrometer – Absorption hygrometer: - Mechanical humidity sensing absorption hygrometer – Electrical humidity sensing absorption hygrometer – Dew point meter.	
TOTAL: 45 PERIODS	

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

CO1: Analyze the functions of force, torque and speed measurement.

CO2: Understand the measurement of acceleration, vibration and density.

CO3: Apply the pressure, temperature measurement techniques.

CO4: Understand the level and flow measurement techniques.

CO5: Apply the viscosity and humidity measurement techniques.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	2	-	-	-	-	-	-	-	3	3
CO2	3	3	3	2	2	-	-	-	-	-	-	-	3	3
CO3	3	3	3	2	2	-	-	-	-	-	-	-	2	3
CO4	3	3	3	3	3	-	-	-	-	-	-	-	3	2
CO5	3	3	3	3	3	-	-	-	-	-	-	-	3	3

TEXT BOOKS:

1. Eckman D.P., “Industrial Instrumentation”, Wiley Eastern Limited, 1990.

2. Singh,S.K., “Industrial Instrumentation and Control”, Tata Mc-Graw-Hill Education Pvt. Ltd., New Delhi, 2009.

3. Jain, R.K., Mechanical and Industrial Measurements, Khanna Publishers, Delhi, 1999.

4. Patranabis, D., “Principles of Industrial Instrumentation”, 3rd Edition, Tata McGraw-Hill
Publishing Company Ltd., New Delhi, 2010.

REFERENCE BOOKS:

1. Doebelin, E.O. and Manik, D.N., “Measurement systems Application and Design”, 6th McGraw-Hill Education Pvt. Ltd, 2011.

2. Liptak, B.G., “Instrumentation Engineers Handbook (Measurement)”, CRC Press, 2005.

WEB RESOURCES:

1. INDUSTRIAL INSTRUMENTATION

https://archive.nptel.ac.in/courses/108/105/108105064/

2. https://kanchiuniv.ac.in/coursematerials/industrial_instrumentation_k_saraswathi.pdf

EE606403-MEDICAL ELECTRONICS

Course Category: Program Elective	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the role of instrumentation in the Biomedical Engineering field.

UNIT 1: HUMAN PHYSIOLOGY SYSTEM **9**

Cells and their structures - action and resting potential - nervous system: functional organization of the nervous system, structure of nervous system, neurons, synapse - transmitters and neural communication –cardiovascular system - basic components of a biomedical system.

UNIT 2: ELECTRO -PHYSIOLOGICAL MEASUREMENTS **9**

Electrodes - Micro, needle and surface electrodes -Amplifiers -Preamplifiers, differential amplifiers, chopper amplifiers.-ECG -EEG -EMG -ERG -EOG -Lead systems and recording methods -Typical waveforms-Electrical safety in medical environment: shock hazards -leakage current-Instruments for checking safety parameters of biomedical equipment.

UNIT 3: NON - ELECTRICAL PARAMETER MEASUREMENT **9**

Measurement of blood pressure - Heart rate - Heart sound - Pulmonary function measurements -spirometer- Body Plethysmography - Blood Gas analyzers: pH of blood - measurement of blood pCO2, pO2, pulse oxymeter.

UNIT 4: MEDICAL IMAGING PARAMETER MEASUREMENTS **9**

X-RAY machine - Computer Tomography - Magnetic Resonance Imaging system - ultrasonography -Endoscopy – biotelemetry. TENS (Transcutaneous Electrical Nerve Stimulation)

UNIT 5: ASSISTING AND THERAPEUTIC DEVICES **9**

Cardiac pacemakers - defibrillators - ventilators - heart lung machine - Dialysers - elements of audio and visual aids - Patient monitoring system.

TOTAL: 45 PERIODS

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

CO1: Understand the basic knowledge of physiology.

CO2: Explore the occurrence of potential and operation of cardiovascular measurements.

CO3: Comprehend the electro-physiological, blood flow and non - electrical parameter measurements.

CO4: Understand the medical imaging parameter measurements.

CO5: Discuss the methods used for monitoring the patients.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	3	-	-	-	-	-	-	-	3	3
CO2	3	3	3	2	2	-	-	-	-	-	-	-	3	3
CO3	3	3	3	3	2	-	-	-	-	-	-	-	2	3
CO4	3	3	3	3	3	-	-	-	-	-	-	-	3	2
CO5	3	3	3	3	3	-	-	-	-	-	-	-	3	3

TEXT BOOKS:

1. R.S.Khandpur, Hand Book of Biomedical instrumentation, Tata McGraw Hill publishing company Ltd., 2014.

REFERENCE BOOKS:

1. J.G. Webster, Medical Instrumentation: Application and Design, John Wiley and Sons, New York, 2010.

2. Leslie Cromwell, Biomedical Instrumentation and measurement, Tata McGraw Hill, 2007.

3. G. Well, Biomedical Instrumentation and Measurements, Prentice Hall of India, New Delhi, 2011.

WEB RESOURCES:

1. BIOMEDICAL INSTRUMENTATION

https://nptel.ac.in/courses/108105101

2. https://nptel.ac.in/courses/108108180

EE606404- PROCESS CONTROL

Course Category: Program Elective	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the dynamic modelling of physical processes.
- To educate various control actions with tuning.
- To impart knowledge on the final control elements.
- To elaborate different types of multiloop control schemes.

UNIT 1: PROCESS MODELLING AND DYNAMICS **9**

Need for Process Control – Mathematical Model of First order Level, Pressure and

Temperature Processes —higher order process - Interacting and Non Interacting Systems – Degrees of freedom -Continuous and Batch Process – Self Regulation process– Servo and Regulatory Operation.

UNIT 2: CONTROL ACTIONS AND CONTROLLERS	**9**

Basic Control actions – Characteristics of On Off, Single Speed Floating, Proportional, Integral and Derivative Control Modes – P+I, P+D, P+I+D Control Modes Pneumatic and electronic Controllers to realize various control actions-PID Implementation Issues: Bumpless, Auto/manual mode transfer, Anti-reset windup techniques – Direct/reverse action.

UNIT 3: OPTIMUM CONTROLLER SETTINGS	**9**

Evaluation criteria – IAE, ISE, ITAE and ¼ decay ratio - Tuning:- Process reaction curve method, Continuous cycling method and Damped oscillation method – Determination of optimum settings for mathematically described processes using time response and frequency response approaches –Auto tuning.

UNIT 4: FINAL CONTROL ELEMENTS	**9**

Signal conversion - I/P, P/I Converters – Pneumatic and Electric Actuators – Control Valves – Characteristics of Control Valves – Construction – Valve Body – Control Valve Sizing – Cavitation and Flashing – Selection Criteria – Valve Positioner.

UNIT 5: MULTILOOP CONTROL	**9**

Feed-forward control – Ratio control – Cascade control – Inferential control – Split-range and introduction to multivariable control – Examples from distillation column and boiler systems –Adaptive control – P&ID diagram.

TOTAL: 45 PERIODS

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

CO1: Develop mathematical models for first order and higher order processes.

CO2: Apply suitable control mode for different applications.

CO3: Analyze the various control schemes and obtain optimum controller settings using tuning Methods.

CO4: Understand the construction, working and selection of final control elements for a closed loop control system.

CO5: Ability to apply complex control schemes for various process applications and draw P&ID diagrams for various processes.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	3	2	-	-	-	-	-	-	-	3	3
CO2	3	3	3	3	2	-	-	-	-	-	-	-	3	3
CO3	3	3	3	2	2	-	-	-	-	-	-	-	3	3
CO4	3	3	3	3	3	-	-	-	-	-	-	-	3	3
CO5	3	3	3	3	3	-	-	-	-	-	-	-	3	3

TEXT BOOKS:

1. Curtis D. Johnson, Process control Instrumentation technology, Pearson new international edition 2013.

2. George Stephanopoulos, Chemical Process Control, PHI learning Pvt. Ltd., New Delhi, 2012.

3. Eckman D P, “Automatic Process Control”, Wiley Eastern Ltd., New Delhi, 1993.

REFERENCE BOOKS:

1. D.R. Coughanowr, Process Systems Analysis and control, McGraw Hill, Singapore, 3rd Edition, 2009.

2. B.Wayne Bequette, Process Control Modelling, Design and Simulation, PHI learning Pvt. Ltd., New Delhi, 2010.

3. Peter Harriott, Process Control, Tata McGraw Hill publishing Co. Ltd., New Delhi, 30th reprint 2010.

4. Bela.G.Liptak., Process Control and Optimization‖., Instrument Engineers Handbook. Volume 2, CRC press and ISA, 2005.

WEB RESOURCES:

1. Process Control - Design, Analysis and Assessment
https://www.digimat.in/nptel/courses/video/103106148/L01.html

2. Introduction to Industrial Automation and Control

https://nptel.ac.in/courses/108105063

EE606405- LOGIC AND DISTRIBUTED CONTROL SYSTEM

Course Category: Program Elective	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To understand the fundamentals of Programmable Logic Controller (PLC), Supervisory Control and Data Acquisition (SCADA) and Distributed Control System (DCS).

UNIT 1: PROGRAMMABLE LOGIC CONTROLLER **9**

Evolution of PLC's – Components of PLC – Advantages over relay logic – Architecture of PLC–Programming devices – Discrete and Analog I/O modules – Programming languages – Ladder diagram – Programming timers and counters – design of PLC – integration of PLC with process.

UNIT 2: APPLICATIOS OF PLC **9**

Instructions in PLC – Program control instructions, math instructions, sequencer instructions – Use of PC as PLC – Case study of bottle filling system – material handling system – automatic stamping system.

UNIT 3: SUPERVISORY CONTROL AND DATA ACQUISITION SYSTEM	**9**

Introduction to SCADA – components of SCADA – features of SCADA – Integration of SCADA system with PLC – SCADA hardware and software – Remote terminal unit – Master station and HMI computer(s) – Communication infrastructure.

UNIT 4: DISTRIBUTED CONTROL SYSTEM	**9**

Evolution – Building blocks – Field controlled units – Operator stations – Data highways – Redundancy concepts – Communication in DCS – DCS system integration with PLC and computers.

UNIT 5: INTERFACES IN DCS	**9**

Operator interfaces – Low and High level operator interfaces – operator displays – Engineering interfaces – Low and High level engineering interface - Factors to be considered in selecting DCS – Case studies in DCS.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will have the

CO1: Ability to develop the PLC program for various applications.

CO2: Ability to extend the PLC operations with various instructions

CO3: Ability to explore the function of supervisory control and data acquisition.

CO4: Ability to analyze with DCS communication protocol for a given application.

CO5: Ability to understand the interfaces of DCS.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2

CO1	3	2	2	3	2	-	-	-	-	-	-	-	3	3
CO2	3	3	3	2	2	-	-	-	-	-	-	-	3	3
CO3	3	3	3	2	2	-	-	-	-	-	-	-	2	3
CO4	3	3	3	3	3	-	-	-	-	-	-	-	3	2
CO5	3	3	3	3	3	-	-	-	-	-	-	-	3	3

TEXT BOOKS:

1. Petruzella, Industrial Electronics‟, McGraw Hill, third edition, 2010.

2. Michael P. Lukas, “Distributed Control System”, Van Nostrand Reinhold Co., Canada, first edition 1986.

3. John. W. Webb Ronald A Reis – Programmable Logic Controllers – Principles and Applications, Fourth edition, Prentice Hall Inc., New Jersey, 1998.

4. S.Ramraj, Process Control, Lakshmi Publications, 2015.

REFERENCE BOOKS:

1. Krishna Kant, “Computer Based Industrial Control” Prentice Hall India, 1997.

2. McMillan, G.K., “Process/Industrial Instrument and Controls Handbook”, 5thEdition, McGraw- Hill handbook, New York, 1999.

WEB RESOURCES:

1. PLC. https://instrumentationtools.com/what-is-a-plc/

2. NPTEL Course, Industrial Automation And Control by Prof. Siddhartha Mukhopadhyay, IIT Kharagpur.
https://archive.nptel.ac.in/noc/courses/noc19/SEM1/noc19-me04/

EE606406- INDUSTRIAL DATA NETWORKS

Course Category: Program Elective	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:		

- To educate on the basic concepts of data networks.
- To introduce the basics of internetworking and serial communications.
- To provide details on HART and Field buses.
- To educate on MODBUS, PROFIBUS and other communication protocols.
- To introduce industrial Ethernet and wireless communication.

UNIT 1: DATA NETWORK FUNDAMENTALS	9

Networks hierarchy and switching – Open System Interconnection model of ISO - Data link control protocol - Media access protocol - Command / response - Token passing - CSMA/CD, TCP/IP.

UNIT 2: INTERNET WORKING AND RS 232, RS485	9

Bridges - Routers - Gateways - Standard ETHERNET and ARCNET configuration special requirement for networks used for control - RS 232, RS 485 -configuration Actuator Sensor (AS) – interface, Devicenet.

UNIT 3: HART AND FIELDBUS	9

Introduction - Evolution of signal standard - HART communication protocol - HART networks -HART commands - HART applications - Fieldbus - Introduction - General Fieldbus architecture - Basic requirements of Fieldbus standard - Fieldbus topology - Interoperability - Interchangeability - Introduction to OLE for process control (OPC).

UNIT 4: MODBUS AND PROFIBUS PA/DP/FMS AND FF	9

MODBUS protocol structure - function codes – troubleshooting Profibus, Introduction, Profibus protocol stack, Profibus communication model - communication objects - system operation - troubleshooting - review of foundation fieldbus - Data Highway.

UNIT 5: INDUSTRIAL ETHERNET AND WIRELESS COMMUNICATION	9

Industrial Ethernet, Introduction, 10 Mbps Ethernet, 100 Mbps Ethernet - Radio and wireless communication, Introduction, components of radio link - radio spectrum and frequency allocation - radio MODEMs-Introduction to wireless HART and ISA100.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student will have the

CO1: Ability to understand the data network fundamentals.

CO2: Ability to understand the internet working and Rs 232 and Rs 485.

CO3: Ability to illustrate, compare and explain the working of HART and Field bus used in process digital communication.

CO4: Ability to summarize the operation of MODBUS, PROFIBUS protocol and its applications.

CO5: Ability to explain and adopt the different Industrial Ethernet protocol and usage of wireless communication in process applications.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	2	-	-	-	-	-	-	-	3	3
CO2	3	3	3	2	2	-	-	-	-	-	-	-	3	3
CO3	3	3	3	3	2	-	-	-	-	-	-	-	2	3
CO4	3	3	3	3	3	-	-	-	-	-	-	-	3	2
CO5	3	3	3	3	3	-	-	-	-	-	-	-	3	3

TEXT BOOKS:

1. Steve Mackay, Edwin Wrijut, Deon Reynders, John Park, Practical Industrial Data Networks Design, Installation and Troubleshooting' Newnes Publication, Elsevier First Edition, 2004

2. William Buchanan, Computer Buses, CRC Press, 2000.

3. Behrouz Forouzan, Data Communications & Networking, 3rd edition, Tata McGraw hill, 2006.

REFERENCE BOOKS:

1. Andrew S. Tanenbaum, David J. Wetherall, Computer Networks, Prentice Hall of India Pvt. Ltd., 5th Edition. 2011.

2. Theodore S Rappaport, Wireless Communication: Principles and Practice, Prentice Hall of India 2nd Edition, 2001.

3. William Stallings, Wireless Communication & Networks, Prentice Hall of India, 2nd Edition, 2005.

WEB RESOURCES:

1. INTRODUCTION OF COMMUNICATION NETWORKS.

https://archive.nptel.ac.in/courses/117/105/117105148/

2. https://archive.nptel.ac.in/courses/108/105/108105062/

EE606407-ROBOTICS AND AUTOMATION

Course Category: Program Elective	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the fundamentals of robotics
- To learn applications of various power sources and sensors used in robots.
- To analyse the importance of manipulators, actuators, and grippers in robots.
- To evaluate the robot kinematics using matrix methods
- To build the robot dynamics to control the manipulators.

UNIT 1: BASICS OF ROBOTICS **9**

Historical Perspective, Asimov's laws of robotics-classification of robots based on Geometry, Workspace, Actuation, Control, and Application- Robot Configurations –Robot Specifications: Number of Axes Internal and External (7-axis robot) - Capacity and Speed, Reach and Stroke, Tool Orientation, Repeatability, Precision and Accuracy, Operating Environment.

UNIT 2: POWER SOURCES AND SENSORS	9

Hydraulic, pneumatic, and electric drives – gear ratio – variable speed arrangements – machine vision – position - ranging – velocity – tactile sensors – Force and torque sensor.

UNIT 3: MANIPULATORS, ACTUATORS AND GRIPPERS	9

Construction of manipulators – manipulator dynamics and force control – electronic and pneumatic manipulator control circuits – end effectors – U various types of grippers – Tools - design considerations.

UNIT 4: ROBOT KINEMATICS	9

Degrees of freedom and mobility- Rotation representation- Coordinate transformations,-DH parameters, Matrix methods for forward and inverse kinematics analyses-Jacobian and Singularity

UNIT 5: ROBOT DYNAMICS AND CONTROL	9

Euler-Lagrange and Newton-Euler equations of motion for robot manipulators- Inverse and forward dynamic analyses- linear control of robot manipulators.

TOTAL: 45 PERIODS

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

CO1 Understand the fundamentals of robotics

CO2 Learn about the applications of various power sources and sensors used in robots.

CO3 Analyse the importance of manipulators, actuators, and grippers in robots.

CO4 Evaluate the robot kinematics using matrix methods

CO5 Build the robot dynamics to control the manipulators.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	2	-	-	-	-	-	-	-	3	3

CO2	3	3	3	2	2	-	-	-	-	-	-	-	3	3
CO3	3	3	3	2	2	-	-	-	-	-	-	-	2	3
CO4	3	3	3	3	3	-	-	-	-	-	-	-	3	2
CO5	3	3	3	3	3	-	-	-	-	-	-	-	3	3

TEXT BOOKS:

1. Craig, J. J., Introduction to Robotics: Mechanics and Control, Pearson, 3rd Edition, 2004.

2. Mikell P.Groover, Mitchell Weiss, Roger, N., Nagel Nicholas, and Odrey, G., "Industrial Robotics Technology, Programming and Applications", McGraw Hill Book Company 2012.

3. Mark W. Spong, Seth Hutchinson, M. Vidyasagar, "Robot Modelling and Control", Wiley, 2012.

REFERENCE BOOKS:

1. Mc Kerrow, P.J., "Introduction to Robotics", Addison Wesley, USA, 2003.

2. Ghosal, Ashitava. Robotics: Fundamental Concepts and Analysis, Oxford, 2006.

3. Spong, Mark W., Seth Hutchinson, and Mathukumalli Vidyasagar. Robot Modelling and Control. Vol. 3. New York: Wiley, 2006

4. Niku S B, "Introduction to Robotics, Analysis, Control, Applications", John-Wiley & Sons Inc, 2011.

5. Siciliano, Bruno, Khatib, Oussama, Springer Handbook of Robotics, Springer, 2016.

WEB RESOURCES:

1. Introduction to Robotics. https://see.stanford.edu/Course/CS223A

2. Introduction to Robotics. https://ocw.mit.edu/courses/2-12-introduction-to-robotics-fall-2005/

3. Modern Robotics: Mechanics, Planning, and Control
https://www.coursera.org/specializations/modernrobotics

EE606408- VIRTUAL INSTRUMENTATION

Course Category: Program Elective	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the basic virtual instrumentation concepts.
- To learn the basics of Data Acquisition System.

UNIT 1: INTRODUCTION **9**

Evolutions of VI, advantages, block diagram and architecture of a virtual instrument-Graphical programming, and comparison with conventional programming.

UNIT 2: VI PROGRAMMING **9**

Controls and indicators- Labels and Text –Shape, size and color- – Data type, Format, Precision and representation – Data types – Data flow programming-Editing – Debugging and Running a Virtual Instrument – Concept of subVI.

UNIT 3: PROGRAMMING STRUCTURE **9**

FOR Loops, WHILE Loops, CASE Structure, Formula nodes, Sequence structures-Attribute modes Local and Global variables.

UNIT 4: ARRAYS AND CLUSTERS **9**

Arrays and Clusters– Array Operations – Bundle – Bundle/Unbundle by name, graphs and charts – String and file I/O.

UNIT 5: HARDWARE INTERFACING **9**

DAQ – Block diagram – Description - basic system components of a signal conditioning system- Interfacing with LabVIEW- Introduction to myRIO.

TOTAL: 45 PERIODS

COURSE OUTCOMES: At the end of the course, the student should have the:

CO1: Paraphrase the basics of VI

CO2: Identify the difference between Graphical and text programming.

CO3: Apply concepts of VI for programming structures and loops.

CO4: Understand the arrays and clusters

CO5: Describe about DAQ architecture and its function

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	2	-	-	-	-	-	-	-	3	3
CO2	3	3	3	2	2	-	-	-	-	-	-	-	3	3
CO3	3	3	3	2	2	-	-	-	-	-	-	-	2	3
CO4	3	3	3	3	3	-	-	-	-	-	-	-	3	2
CO5	3	3	3	3	3	-	-	-	-	-	-	-	3	3

TEXT BOOKS:

1. Gary Johnson, Richard Jennings, Lab VIEW Graphical Programming, McGraw Hill, New York, fourth Edition, 2006.

2. Jovitha Jerome, Virtual Instrumentation using LabVIEW, PHI Publishers, New Delhi, Second Edition 2010.

REFERENCE BOOKS:

1. Lab VIEW: Basics I & II Manual, National Instruments, Bangalore, 2005.

2. D Kevin James, PC Interfacing and Data Acquisition: Techniques for Measurement, Instrumentation and Control, Newnes, 2000.

WEB RESOURCES:

1. VIRTUAL INSTRUMENTATION USING LABVIEW

https://www.acte.in/virtual-instrumentation-using-labview-article/

2. VIRTUAL INSTRUMENTATION

https://www.ni.com/en-in/shop/labview/virtual-instrumentation.html

EE606409- COMPUTER CONTROL OF PROCESSES

Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To represent the linear time invariant System in discrete State Space form.
- To analyze the controllability, observability and stability of a Discrete time System.
- To estimate model parameters from input/output measurements
- To Design Digital Controllers
- To Design Multi-loop and Multivariable Controllers for multivariable system

UNIT 1: DISCRETE STATE-VARIABLE TECHNIQUE **9**

State equation of discrete data system with sample and hold – State transition equation – Methods of computing the state transition matrix – Decomposition of discrete data transfer functions – State diagrams of discrete data systems – System with zero-order hold – Controllability and observability of linear time invariant discrete data system–Stability tests of discrete-data system.

UNIT 2: SYSTEM IDENTIFICATION **9**

Review of z-transform – Modified z-transform – Pulse transfer function – Digital PID controller – Dead-beat controller and Dahlin's controller – IMC - Smith Predictor.

UNIT 3: DIGITAL CONTROLLER DESIGN **9**

Review of z-transform – Modified of z-transform – Pulse transfer function – Digital PID

controller – Dead-beat controller and Dahlin's controller – IMC - Smith Predictor.

UNIT 4: MULTI-LOOP REGULATORY CONTROL	**9**

Multi-loop Control - Introduction – Process Interaction – Pairing of Inputs and Outputs - The Relative Gain Array (RGA) – Properties and Application of RGA - Multi-loop PID Controller – Biggest Log Modulus Tuning Method – De-coupler.

UNIT 5: MULTIVARIABLE REGULATORY CONTROL	**9**

Introduction to Multivariable control –Multivariable PID Controller – Multivariable Dynamic Matrix Controller – Fuzzy Logic Controller – Case Studies:- Distillation Column, CSTR and Four-tank system.

TOTAL: 45 PERIODS

COURSE OUTCOMES: Having successfully completed this course students should be able to

CO1: Analyze the discrete time systems.

CO2: Build models from input-output data.

CO3: Design a digital controller.

CO4: Design multi-loop controllers for multi-variable systems.

CO5: Design multivariable controllers for multi-variable systems.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	2	-	-	-	-	-	-	-	3	3
CO2	3	3	3	2	2	-	-	-	-	-	-	-	3	3
CO3	3	3	3	2	2	-	-	-	-	-	-	-	2	3
CO4	3	3	3	3	3	-	-	-	-	-	-	-	3	2
CO5	3	3	3	3	3	-	-	-	-	-	-	-	3	3

TEXT BOOKS:

1. Stephanopoulos, G., "Chemical Process Control -An Introduction to Theory and Practice", Prentice Hall of India, 2009.

2. Franklin, G.F., "Michael Workman & Powel J.D - Digital Control of Dynamic Systems", Pearson Education; 3rd edition (fifth Indian reprint) edition, 2005.

REFERENCE BOOKS:

1. Gopal, M., "Digital Control & Static variable methods", 4th edition Tata McGraw-Hill Education 2012.

2. Chidambaram, M., "Computer Process Control", CRC Press INC, 2002.

3. Deshpande, P.B., and Ash, R.H., "Computer Process Control - ISA publication", USA 2012.

4. Sigurd Skogestad, Ian Postlethwaite, "Multivariable Feedback Control: Analysis and Design", John Wiley and Sons, 2005.

WEB RESOURCES:

1. PROCESS CONTROL - DESIGN, ANALYSIS AND ASSESSMENT

https://www.digimat.in/nptel/courses/video/103106148/L01.html

2. CHEMICAL PROCESS CONTROL

https://archive.nptel.ac.in/courses/103/101/103101142/

3. MODEL PREDICTIVE CONTROL: THEORY AND APPLICATIONS

https://onlinecourses.nptel.ac.in/noc21_ge01/preview

EE606410- INSTRUMENTATION SYSTEM DESIGN

Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:		

- To understand the design perspectives of Sensors and Controllers.

UNIT 1: DESIGN OF SIGNAL CONDITIONING CIRCUITS	9

Design of V/I and I/V converters – Analog and Digital filter design- Signal conditioning circuit for pH measurement – Temperature compensation circuit - software and hardware approaches - Thermistor linearization.

UNIT 2: DESIGN OF TRANSMITTERS	9

RTD and thermocouple based temperature transmitter- Capacitance based level transmitter – Air purge system for level measurement – Smart transmitters.

UNIT 3: DESIGN OF DATA ACQUISITION SYSTEM AND CONTROLLERS	9

Design of ON / OFF controller using linear integrated circuits- Electronic PID controller- Selection of ADC and DAC - Microcontroller based design: Measurement system and digital PID controller.

UNIT 4: DESIGN OF ORIFICE AND ROTAMETER, CONTROL VALVE SIZING	9

Orifice Sizing – Liquid, gas and steam services – Rotameter design - Control valves – Valve body- Commercial valve bodies- Control valve sizing– Liquid, gas and steam services- Selection criteria.

UNIT 5: DESIGN OF ALARM AND ANNUNCIATION CIRCUIT	9

Alarm and Annunciator circuits - Thyristor Power Controller – Design of Interlocks- software and hardware approaches.

TOTAL: 45 PERIODS

COURSE OUTCOMES: Having successfully completed this course students should be able to

CO1: Design the signal conditioning circuits.

CO2: Design the transmitters

CO3: Design of data acquisition system and controllers.

CO4: Design the orifice and rotameter and sizing the control valve.

CO5: Design the alarm and annunciator circuit.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	2	-	-	-	-	-	-	-	3	3
CO2	3	3	3	2	2	-	-	-	-	-	-	-	3	3
CO3	3	3	3	2	2	-	-	-	-	-	-	-	2	3
CO4	3	3	3	3	3	-	-	-	-	-	-	-	3	2
CO5	3	3	3	3	3	-	-	-	-	-	-	-	3	3

TEXT BOOKS:

1. John P Bentley, “Principles of Measurement Systems”, Pearson Education, 2004

2. C. D. Johnson, “Process Control Instrumentation Technology”, Pearson Education, 2005

REFERENCE BOOKS:

1. Miller R. W., Flow Measurement Engineering Handbook, McGraw Hill, New York, 1996.

2. Gregory K Mc Millan Douglas M Considine, Process/ Industrial Instruments and Controls Handbook, Tata McGraw Hill, 2009.

3. Norman.A.Anderson, Instrumentation for Process Measurement and Control, CRC Press, 2010.

4. Andrew W G Williams H B, Applied Instrumentation in the Process Industries, Houghton Mifflin Com, 2002.

WEB RESOURCES:

1. INDUSTRIAL INSTRUMENTATION https://archive.nptel.ac.in/courses/108/105/108105064/
2. https://kanchiuniv.ac.in/coursematerials/industrial_instrumentation_k_saraswathi.pdf

STREAM 5 – GREEN TRANSPORTATION

EE606501-ELECTRIC VEHICLE DESIGN						
Course Category: Program Elective	**Course Type: Theory**		**L**	**T**	**P**	**C**
			3	**0**	**0**	**3**
COURSE OBJECTIVES:						
• To model and design of electric vehicle technology with high efficiencies • To Evaluate Various choices available to designers to optimize their vehicle design • To analyse various electric drives and controller suitable for electric vehicles. • To design and choice of ancillaries such as the heating and cooling system • To investigate the need for further research in promising areas.						
UNIT I ELECTRIC VEHICLE MODELLING						**9**
Tractive Effort - Rolling resistance force - Aerodynamic drag - Hill climbing force - Acceleration force - Total tractive effort - Modelling Vehicle Acceleration – Acceleration performance parameters - Modelling the acceleration of a small car - Modelling Electric Vehicle Range - Driving cycles - Range modelling of battery electric vehicles - Constant velocity range modelling - Range modelling of fuel cell vehicles - Range modelling of hybrid electric vehicles						
UNIT II ELECTRIC VEHICLE DESIGN CONSIDERATIONS						**9**
Transmission Efficiency - Consideration of Vehicle Mass - Electric Vehicle Chassis and Body Design - Body/chassis requirements - Body/chassis layout - Body/chassis strength, rigidity and crash resistance - Designing for stability - Suspension for electric vehicles - Chassis used in modern fuel cell electric vehicles						
UNIT III SERIES HYBRID ELECTRIC DRIVE TRAIN DESIGN						**9**

Operation Patterns - Control Strategies - maximum state-of-charge of peaking power source (PPS) - Thermostat Control Strategy (Engine-On–Off) - Sizing of the Major Components - Power Rating Design of the Traction Motor - Power Rating Design of the Engine/Generator - Design of PPS - Power Capacity of PPS - Energy Capacity of PPS

UNIT IV PARALLEL HYBRID ELECTRIC DRIVE TRAIN DESIGN **9**

Control Strategies of Parallel Hybrid Drive Train - Maximum State-of-Charge of Peaking Power Source (Max. SOC-of- PPS) Control Strategy - Engine Turn-On and Turn-Off (Engine-On–Off) Control Strategy Design of Drive Train Parameters - Design of Engine Power Capacity - Design of Electric Motor Drive Power Capacity - Transmission Design
- Energy Storage Design

UNIT V ANCILLARY SYSTEMS AND THE ENVIRONMENT **9**

Feeders - distributors and service mains- DC 2-wire distributor – radial and ring main distribution. AC distribution – single phase (with concentrated and distributed loads) and three phase 3-wire and 4-wire distribution with balanced and unbalanced loads.

TOTAL: 45 PERIODS

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

CO1: Understand the given design specification and model the various components required for electrical vehicles with high performance.

CO2: Choose proper drives and control for developing a new electric vehicle

CO3: Describe the behavior of electric vehicle by sophisticated mechanical and mathematical knowledge.

CO4: To evaluate an electrical vehicle design

CO5: Identify the choice of ancillaries such as the heating and cooling system

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	2	1	1	2	2	-	2	2	3	3	3	2
CO2	3	1	2	1	1	2	2	-	2	2	3	3	3	2
CO3	3	1	2	1	2	2	2	-	2	2	3	3	3	2
CO4	3	1	2	1	2	2	2	-	2	2	3	3	3	2
CO5	3	1	2	1	2	2	2	-	2	2	3	3	3	2

TEXT BOOKS:

1. Qian, Huihuan, et al. Hybrid Electric Vehicle Design and Control: Intelligent Omnidirectional Hybrids. United States, McGraw Hill LLC, 2013.
2. Mehrdad Ehsani, Yimin Gao, Stefano Longo Kambiz M. Ebrahimi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles", CRS Press, 2018.
REFERENCE BOOKS:
1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2011
2. Seref Soylu "Electric Vehicles - The Benefits and Barriers" InTech Publishers, Croatia, 2011
3. Amir Khajepour, M. Saber Fallah, Avesta Goodarzi "Electric and hybrid vehicles technologies, modelling and control: a mechatronic approach" John Wiley & Sons Ltd 2014.
WEB RESOURCES:
1.Electric Vehicle: https://onlinecourses.nptel.ac.in/noc23_ee01/preview
1.Fundamental of Electric Vehicle: https://archive.nptel.ac.in/courses/108/106/108106170/

EE606502-VEHICLE DYNAMICS AND CONTROL						
Course Category: Program Elective	**Course Type: Theory**		**L**	**T**	**P**	**C**
			3	**0**	**0**	**3**
COURSE OBJECTIVES:						
• To learn about the design of vehicle control system, traction and brake, ride and handling dynamics for each vehicle are needed. • To learn about the fundamental theory of vehicle dynamics, vehicle performance as well as related tests. • To learn about the application of the dynamic modelling and analysis approach in vehicle design. • To develop students' capabilities of analysis, evaluation and design based on their acquisition of skills in modelling dynamic equation and performance analysis.						
UNIT I INTRODUCTION TO VEHICLE DYNAMICS AND CONTROL						**9**
Definition of the vehicle, virtual four-wheel vehicle model, control of motion, driver assistance systems, active stability control systems, ride quality, technologies for addressing traffic Congestion. Forward vehicle dynamics: packed car on a level road, packed car on a level road, accelerating car on a level road, accelerating car on an inclined road, parked car on a banked road, optimal drive and brake force distribution, vehicles on a crest and dip.						

UNIT II TYRE MECHANICS	9
Tyre and Rim fundamentals: Tyre and sidewall information, Tyre components, Tyre and side-slip angle, Radial and non-radial tyres, Thread, Hydroplaning, tyreprint, wheel and rim, vehicle classifications. Tyre Dynamics: Tyre Coordinate Frame and Tyre Force System, Tyre Stiffness, Tyreprint Forces, Effective Radius, Rolling Resistance, rollover index , rollover prevention , tyre cornering characteristics, traction, braking, and cornering characteristics, dynamic characteristics, vehicle dynamic characteristics.	
UNIT III VEHICLE MECHANISMS AND CONTROL	**9**
Steering Dynamics: Kinematic Steering, Ackerman mechanism, Langensperger steering, rear-wheel steering, Vehicles with More Than Two Axles, Vehicle with Trailer, Steering Mechanisms & types, Four wheel steering, Trailer-Truck Kinematics, Suspension Mechanisms: Solid Axle Suspension, active, semi-active, and passive suspension, Independent Suspension, Roll Center and Roll Axis, Car Tyre Relative Angles, Toe-in and toe-out, Suspension Requirements and Coordinate, Frames, Caster Theory.	
UNIT IV VEHICLE DYNAMICS	**9**
Applied dynamics: Force and Moment of vehicle, Rigid Body Translational Dynamics, Rigid Body Rotational Dynamics, Mass Moment of Inertia Matrix, Lagrange's Form of Newton's Equations of Motion, Lagrangian Mechanics, Vehicle Roll Dynamics: Vehicle Coordinate and DOF, Equations of Motion, Vehicle Force System, Two-wheel Rigid Vehicle Dynamics, Steady-State Motion, time response..	
UNIT V VIBRATION AND VEHICLE CONTROL	**9**
Applied Vibrations: Mechanical Vibration Elements, Newton's Method and Vibrations, Frequency Response of Vibrating Systems, Time Response of Vibrating Systems. Vehicle Vibrations: Lagrange Method and Dissipation Function, Quadratures, Natural Frequencies and Mode Shapes, Full Car Vibrating Model. Vehicle control: Steering control, Longitudinal controls, anti-lock brake systems, adaptive cruise control, control architectures, electronic stability control, steer-by-wire systems, need for slip angle control	
TOTAL: 45 PERIODS	
COURSE OUTCOMES: At the end of the course, the student will be able to	
CO1:Understand the fundamentals of vehicle dynamics and its controls	
CO2: Know the tyre and rim fundaments and the tyre mechanism.	
CO3: Know vehicle mechanism, steering and suspension mechanism.	

CO4: Know the vertical dynamics of road vehicles and to simulate and analyze vehicle performance as well.

CO5: Understand the concept and anlaysis of vibration and control of the vehicle system

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	2	1	1	2	2	-	1	2	1	3	2	1
CO2	3	1	2	1	1	2	2	-	1	2	1	3	2	1
CO3	3	1	2	1	1	2	2	-	1	2	1	3	2	1
CO4	3	1	2	1	1	2	2	-	1	2	1	3	2	1
CO5	3	1	2	1	1	2	2	-	1	2	1	3	2	1

TEXT BOOKS:

1. Kazemi, Reza, et al. Vehicle Dynamics and Control: Advanced Methodologies. Netherlands, Elsevier Science, 2021.

REFERENCE BOOKS:

1. Basilio Lenzo, Vehicle Dynamics: Fundamentals and Ultimate Trends. Switzerland, Springer International Publishing, 2021.

2. Rajesh Rajamani, Vehicle Dynamics and Control, Second Edition, Mechanical Engineering Series book series (MES), Springer, 2012.

3. Hans B. Pacejka, Tyre and vehicle dynamics", Butterworth-Heinemann of Elsevier, second edition, 2006.

WEB RESOURCES:

E-mobility and vehicle dynamics. https://elearn.nptel.ac.in/shop/iit-workshops/completed/e-mobility-and-electric-vehicle-engineering/

Vehicle dynamics. https://archive.nptel.ac.in/courses/107/106/107106080/

EE606503-MODELLING, SIMULATION AND CONTROL OF ELECTRIC VEHICLES

Course Category: Program Elective	**Course Type: Theory**		**L**	**T**	**P**	**C**
			3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To model Electric motors, Power Converters, Battery and Ultracapacitor.
- To control the Electric Drives
- To study the Energy Management Strategies in Hybrid and Electric Vehicles

UNIT I SYSTEM MODELLING AND REPRESENTATION	**9**
System concepts- Transfer function Modelling of Electrical systems, Mechanical systems (Translational & Rotational systems)- Electrical Analogy of Mechanical Systems – Park and Clark transformation.	
UNIT II MODELLING OF ELECTRIC MOTORS	**9**
Modelling of DC motor- Modelling of Induction motor- Modelling of PMSM- Modelling of BLDC motor	
UNIT III MODELLING OF POWER CONVERTERS AND BATTERY	**9**
Modelling of Buck converter- Modelling of Boost converter- Modelling of Inverter- Modelling of Bidirectional DC- DC	
UNIT IV CONTROL OF ELECTRIC DRIVES	**9**
Scalar control-Field oriented control technique- Direct Torque based control technique- Speed Control of BLDC Motor	
UNIT V CONTROL SYSTEM FOR HYBRID AND ELECTRIC VEHICLE	**9**
Function of the Control System in HEVs and EVs-Energy Management Strategies-Rule and Optimization based Energy management Strategies-EMS based on deterministic Rules	
TOTAL: 45 PERIODS	
COURSE OUTCOMES: At the end of the course, the student will be able to	
CO1: Develop mathematical models of electrical and mechanical systems	
CO2: Explain the Modelling of Electric Motors used in Hybrid and Electric vehicle.	
CO3: Explicate the Modelling of Power Converters and Battery used in Hybrid and Electric vehicle	
CO4: Narrate on controlling of Electric Drives	
CO5: Develop Energy Management rules to control Hybrid and Electric vehicle	

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	2	-	2	2	2	2	1	2	1	3	3	3
CO2	3	-	2	-	2	2	2	2	1	2	1	3	3	3
CO3	3	-	2	-	2	2	2	2	1	2	1	3	3	3
CO4	3	-	2	-	2	2	2	2	1	2	1	3	3	3
CO5	3	-	2	-	2	2	2	2	1	2	1	3	3	3

TEXT BOOKS:
1.SerefSoylu, “Electric Vehicles: Modelling and Simulations” , InTech Publications, 2011
2. Wei Liu, “Hybrid Electric Vehicle System Modelling and Control”, Second Edition, Wiley Publications, 2017
3. Gopal M, “Control Systems – Principles and Design, Tata McGraw-Hill, New Delhi, 2013
REFERENCE BOOKS:
1. Krishnan R., “ Electric Motor & Drives: Modelling, Analysis and Control”, Pearson Education, 2015
WEB RESOURCES:
Electric Vehicles: https://nptel.ac.in/courses/108103009/

EE606504-DESIGN OF MOTOR AND POWER CONVERTERS FOR ELECTRIC VEHICLES						
Course Category: Program Elective	**Course Type: Theory**		**L**	**T**	**P**	**C**
			3	**0**	**0**	**3**
COURSE OBJECTIVES:						
• To review the drive cycles and requirements of EVs • To know the working of motors used in Electric Vehicle • To analyze and model the buck/boost converter operation and to design the same • To learn the simulation basics of control systems • To derive transfer functions for DC-DC converters						
UNIT I ELECTRIC VEHICLE DYNAMICS		**9**				
Standard drive cycles-Dynamics of Electric Vehicles-Tractive force-Maximum speed, torque, power, energy requirements of EVs.						
UNIT II MOTORS FOR ELECTRIC VEHICLES		**9**				
Introduction – Speed And Torque control of above and below rated speed-Speed control of EV in the constant power region of electric motors. DC Motors, Induction Motor, Permanent Magnet Synchronous Motors (PMSM), Brushless DC Motors, Switched Reluctance Motors (SRMs). Synchronous Reluctance Machines-Choice of electric machines for EVs.						
UNIT III BASICS OF SIMULATION IN CONTROL SYSTEMS		**9**				

Transfer Function-How to build transfer function, identify Poles, zeros, draw time response plots, bode plot (Bode Plots for Multiplication Factors, Constant, Single and Double Integration Functions, Single and Double Differentiation Functions, Single Pole and Single Zero Functions, RHP Pole and RHP Zero Functions), state space modelling-transfer function from state space Model.

UNIT IV MODELLING OF DC-DC CONVERTERS **9**

Overview of PWM Converter Modelling -Power Stage Modelling - PWM Block Modelling - Voltage Feedback Circuit and Small-Signal Model of PWM Converter - Averaging Power Stage Dynamics - Average Models for buck/boost Converter - Small-Signal Model of Converter Power Stage - Frequency Response of Converter

UNIT V POWER STAGE TRANSFER FUNCTIONS OF DC – DC CONVERTERS **9**

Power Stage Transfer Functions of buck-boost Converter in CCM Operation, Input-to-Output Transfer Function, Duty Ratio-to-Output Transfer Function, Load Current-to-Output Transfer Function.

TOTAL: 45 PERIODS

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

CO1: To use appropriate electric machine for electric vehicle application.

CO2: To compute transfer function with factors such as constant, integral, differential, first order factor and second order factor (both numerators & denominators)

CO3: To compute transfer function from state models

CO4: To design buck, boost and buck-boost converter.

CO5: To compute a power stage transfer functions for DC-DC converters.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	2	-	1	2	2	-	2	2	3	3	3	2
CO2	3	-	2	-	1	2	2	-	2	2	3	3	3	2
CO3	3	-	2	-	1	2	2	-	2	2	3	3	3	2
CO4	3	-	2	-	1	2	2	-	2	2	3	3	3	2
CO5	3	-	2	-	1	2	2	-	2	2	3	3	3	2

TEXT BOOKS:

1. Power Electronic Converters, Teuvo Suntio, Tuomas Messo, Joonas Puukko, First Edition 2017.

2. Alexander, S. Albert, and Kumar, L. Ashok. “Power Converters for Electric Vehicles”. United Kingdom, CRC Press, 2020.

3. Emerging Power Converters for Renewable Energy and Electric Vehicles Modelling, Design, and Control, Md. Rabiul Islam,Md. Rakibuzzaman Shah, Mohd. Hasan Ali, CRC Press, 2021, 1st Edition.

REFERENCE BOOKS:

1. Electrical Machine Fundamentals with Numerical Simulation using MATLAB/SIMULINK, Atif Iqbal, Shaikh Moinoddin, Bhimireddy Prathap Reddy, Wiley, 2021, 1st Edition.

2. Iqbal Hussain, “Electric and Hybrid Vehicles: Design Fundamentals, Second Edition” CRC Press, Taylor & Francis Group, Third Edition 2021.

WEB RESOURCES:

1. Electrical Vehicle Design: https://onlinecourses.nptel.ac.in/noc23_ee38/preview

2. Design of power Electronics Converter: https://archive.nptel.ac.in/noc/courses/noc22/SEM1/noc22-ee33/

EE606505-DESIGN OF ELECTRIC VEHICLE CHARGING SYSTEM

Course Category: Program Elective	Course Type: Theory		L	T	P	C
			3	0	0	3

COURSE OBJECTIVES:

- To know the charging station and standards
- To learn the concepts of power converters in charging
- To find the charging scheme in renewable based EV charging
- To demonstrate the wireless power transfer technique
- To design & simulate power factor correction circuits

UNIT I CHARGING STATIONS AND STANDARDS	**9**

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

UNIT II POWER ELECTRONICS FOR EV CHARGING	**9**

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

UNIT III EV CHARGING USING RENEWABLE AND STORAGE SYSTEMS	**9**

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

UNIT IV WIRELESS POWER TRANSFER	**9**

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

UNIT V POWER FACTOR CORRECTION IN CHARGING SYSTEM	**9**

Need for power factor correction- Boost Converter for Power Factor Correction, Sizing the Boost Inductor, Average Currents in the Rectifier and calculation of power losses.

TOTAL: 45 PERIODS

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

CO1: To illustrate various charging techniques and to know charging standards and regulations.

CO2: To demonstrate the working of DC-DC converters used for charging systems and principles

CO3: To illustrate the advantages of renewable system based charging systems

CO4: To analyze the standards for wireless charging

CO5: To design and simulate boost converter based power factor correction.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	-	-	2	2	-	3	-	3	3	--
CO2	3	3	3	3	-	-	2	2	-	3	-	3	3	3
CO3	3				-	-			-		-		3	3

CO4	3	3	3	3	-	-	2	2	-	2	-	1	3	3
CO5	3	-	-	-	-	-	-	-	-	-	-	-	3	3

TEXT BOOKS:

1. Mobile Electric Vehicles Online Charging and Discharging, Miao Wang Ran Zhang Xuemin (Sherman) Shen, Springer 2016, 1st Edition.

2. Alicia Triviño-Cabrera, José M. González-González, José A. Aguado, Wireless Power Transferor Electric Vehicles: Foundations and Design Approach, Springer Publisher 1st Edition. 2020.

3. Nil Patel, Akash Kumar Bhoi, Sanjeevikumar Padmanaban, Jens Bo Holm-Nielsen, Electric Vehicles Modern Technologies and Trends. Springer Publisher 1st Edition, 2021.

REFERENCE BOOKS:

1. Cable Based and Wireless Charging Systems for Electric Vehicles, Technology and control, management and grid integration, Rajiv Singh, Sanjeevikumar Padmanaban, Sanjeet Dwivedi, Marta Molinas and Frede Blaabjerg, IET 2021, 1st Edition.

2. Electric and Hybrid Electric Vehicles, James D Halderman, Pearson, 2022, 1st Edition.

3. Handbook of Automotive Power Electronics and Motor Drives, Ali Emadi, Taylor & Francis, 2005.

WEB RESOURCES:

Electrical vehicle Engineering: https://nptel.ac.in/courses/108106170

EE606506-TESTING OF ELECTRIC VEHICLES

Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To know various standardization procedures
- To learn the testing procedures for EV & HEV components
- To know the functional safety and EMC
- To realize the effect of EMC in EVs
- To study the effect of EMI in motor drives and in DC-DC converter system

UNIT I EV STANDARDIZATION **9**

Introduction - Current status of standardization of electric vehicles, electric Vehicles and Standardization - Standardization Bodies Active in the Field – Standardization activities in

countries like Japan. The International Electro Technical Commission - Standardization of Vehicle Components.	
UNIT II TESTING OF ELECTRIC MOTORS AND CONTROLLERS FOR ELECTRIC AND HYBRID ELECTRIC VEHICLES	**9**
Test Procedure Using M-G Set, electric motor, controller, application of Test Procedure, Analysis of Test Items for the Type Test - Motor Test and Controller Test (Controller Only). - Test Procedure Using Eddy Current Type Engine Dynamometer, Test Strategy, Test Procedure, Discussion on Test Procedure. Test Procedure Using AC Dynamometer.	
UNIT III FUNDAMENTALS OF FUNCTIONAL SAFETY AND EMC	**9**
Functional safety life cycle - Fault tree analysis - Hazard and risk assessment – software development - Process models - Development assessments - Configuration management - Reliability- Reliability block diagrams and redundancy - Functional safety and EMC - Functional safety and quality - Standards - Functional safety of autonomous vehicles.	
UNIT IV EMC IN ELECTRIC VEHICLES	**9**
Introduction - EMC Problems of EVs, EMC Problems of Motor Drive, EMC Problems of DC-DC Converter System, EMC Problems of Wireless Charging System, EMC Problem of Vehicle Controller, EMC Problems of Battery Management System, Vehicle EMC Requirements	
UNIT V EMI IN MOTOR DRIVE AND DC-DC CONVERTER SYSTEM	**9**
Overview -EMI Mechanism of Motor Drive System, Conducted Emission Test of Motor Drive System, IGBT EMI Source, EMI Coupling Path, EMI Modelling of Motor Drive System. EMI in DC-DC Converter, EMI Source, The Conducted Emission High-Frequency, Equivalent Circuit of DC-DC Converter System, EMI Coupling Path	
	TOTAL: 45 PERIODS
COURSE OUTCOMES: At the end of the course, the student will be able to	
CO1: To describe the status and other details of standardization of EVs.	
CO2: To illustrate the testing protocols for EVs and HEV components	
CO3: To analyze the safety cycle and need for functions safety for EVs	
CO4: To analyze the problems related with EMC for EV components.	
CO5: To evaluate the EMI in motor drive and DC-DC converter system.	

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	1	-	-	-	2	-	-	-	-	-	3	-
CO2	3	1	1	-	-	-	1	-	-	-	-	-	3	-
CO3	3	1	1	-	-	-	2	-	-	-	-	-	3	-
CO4	3	1	1	-	-	-	1	-	-	-	-	-	3	-
CO5	3	1	1	-	-	-	2	-	-	-	-	-	3	-

TEXT BOOKS:

1. Ali Emadi, Taylor & Francis, Handbook of Automotive Power Electronics and Motor Drives, 2005, 1st Edition.

2. Li Zhai, Springer, Electromagnetic Compatibility of Electric Vehicle, 2021, 1st Edition.

3. Kai Borgeest, EMC and Functional Safety of Automotive Electronics, IET 2018, 1st Edition.

REFERENCE BOOKS:

1. Omar M.Ramachi, EMI/EMC Computational Modelling Handbook, Druce Archam beault, colin branch, Springer 2012, 2nd Edition.

2. Mark Steffika, Automotive EMC, Springer 2013, 1st Edition.

3. Beate Müller, Gereon Meyer, Electric Vehicle Systems Architecture and Standardization Needs, Reports of the PPP European Green Vehicles Initiative, Springer 2015, 1st Edition.

WEB RESOURCES:

Electrical vehicle testing: https://onlinecourses.nptel.ac.in/noc23_ee01/preview

EE606507-GRID INTEGRATION OF ELECTRIC VEHICLES

Course Category: Program Elective	**Course Type: Theory**		**L**	**T**	**P**	**C**
			3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To know the basic details of V2G
- To study the benefits & challenges of V2G
- To learn EV & V2G on the smart grids renewable energy systems
- To know the grid integration

UNIT I DEFINITION AND STATUS OF V2G — **9**

Defining Vehicle to Grid (V2G) - History and Development of V2G. Incorporating V2G to the EV, Auditing and Metering, V2G in Practice, V2G - Power Markets and Applications.

Electricity Markets and V2G Suitability, Long-Term Storage, Renewable Energy, and Other Grid Applications, Beyond the Grid: Other Concepts Related to V2G and G2V.	
UNIT II BENEFITS AND CHALLENGES OF V2G	**9**
Benefits of V2G, Technical Benefits: Storage Superiority and Grid Efficiency, Economic Benefits: EV Owners and Societal Savings, Environment and Health Benefits: Sustainability in Electricity and Transport, Other Benefits.	
UNIT III CHALLENGES TO V2G	**9**
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. Other V2G Regulatory and Legal Challenges.	
UNIT IV IMPACT OF EV AND V2G ON THE SMART GRID AND RENEWABLE ENERGY SYSTEMS	**9**
Introduction - Types of Electric Vehicles - Motor Vehicle Ownership and EV Migration - Impact of Estimated EVs on Electrical Network - Impact on Drivers and the Smart Grid - Standardization and Plug-and-Play - IEC 61850 Communication Standard and IEC 61850-7-420 Extension.	
UNIT V GRID INTEGRATION AND MANAGEMENT OF EVS	**9**
Introduction - Machine to Machine (M2M) in distributed energy management systems - M2M communication for EVs - M2M communication architecture (3GPP) - Electric vehicle data logging - Scalability of electric vehicles -M2M communication with scheduling.	
TOTAL: 45 PERIODS	
COURSE OUTCOMES: At the end of the course, the student will be able to	
CO1: Understand the concepts related with V2G	
CO2: Study the grid connection of 3 phase Q inverter	
CO3: Understand the technical, economics. business, regulatory & political challenges related with V2G	
CO4: Demonstrate the impact of EV and V2G on smart grid and renewable energy system	
CO5: Understand the concept of grid integration and management of EVs.	

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	1	-	-	-	2	1	-	2	1	-	3	3
CO2	3	3	1	-	3	-	2	1	-	2	1	-	3	-
CO3	3	-	1	-	-	-	2	1	-	2	1	-	3	-
CO4	3	-	1	-	-	-	2	1	-	2	2	-	3	-
CO5	3	-	1	-	-	-	2	1	-	2	1	-	3	-

TEXT BOOKS:

1. Ali Emadi, Advanced Electric Drive Vehicles, CRC Press 2017, 1st Edition.

2. Sumedha Rajakaruna , Farhad Shahnia and Arindam Ghosh, Plug In Electric Vehicles in Smart Grids, Charging Strategies, Springer,2015, 1st Edition.

3. Nand Kishor, ICT for Electric Vehicle Integration with the Smart Grid, Jesus Fraile-Ardanuy, IET 2020, 1st Edition.

REFERENCE BOOKS:

1. Junwei Lu and Jahangir Hossain, Vehicle-to-Grid: Linking Electric Vehicles to the Smart Grid, IET 2015, 1st Edition.

2. Lance Noel · Gerardo Zarazua de Rubens Johannes Kester · Benjamin K. Sovacool, Vehicle- to-Grid A Sociotechnical Transition Beyond Electric Mobility, 2019, 1st Edition.

WEB RESOURCES:

Smart Grid: https://onlinecourses.nptel.ac.in/noc23_ee60/preview

EE606508-FUNDAMENTALS OF ELECTRIC AND HYBRID VEHICLES

Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To know the fundamental of electric and hybrid vehicle.
- To understand working principle of electric propulsion system.
- To know the energy storage techniques for electric and hybrid vehicles.
- To know the concept of regenerative braking system.
- To understand concept of fuel cell vehicle.

UNIT I ELECTRIC VEHICLES **9**

Introduction - Configurations of Electric Vehicles, Performance of electric vehicles – Traction motor characteristics, tractive effort, transmission requirements, vehicle

performance, Tractive Effort in Normal Driving, energy consumption, advantage and limitations – Autonomous Vehicles.

UNIT II HYBRID ELECTRIC VEHICLES	**9**

Introduction - Need for HEV - Architectures of Hybrid Electric Drive Trains- Series Hybrid Electric Drive Trains- Parallel Hybrid Electric Drive Trains - Torque coupling, speed coupling and both – Electric and hybrid vehicles comparison – Case studies.

UNIT III ELECTRIC PROPULSION SYSTEMS	**9**

DC motor drives- Principle of Operation and Performance- induction motor drives- Basic Operation Principles & Steady-State Performance - Permanent magnetic BLDC motor drives - Basic Principles & Construction and Classification - switched reluctance motor drives - Basic Magnetic Structure, Torque Production, SRM Drive Converter, Modes of Operation.

UNIT IV ENERGY STORAGES AND REGENERATIVE BRAKING	**9**

Basics of Electrochemical batteries - Ultra-capacitors- Ultra high-Speed Flywheels - Regenerative braking - Braking energy consumed in urban driving – braking energy vs vehicle speed, braking power, vehicle speed, vehicle deceleration rate – braking energy on front and rear axles – brake system of EV, HEV and FCV.

UNIT V FUEL CELLS	**9**

Principles of Fuel Cells-Fuel Cell Technologies- Proton Exchange Membrane, Alkaline, Phosphoric Acid, Molten Carbonate, Solid Oxide, Direct Methanol fuel cells - Fuel Supply- Hydrogen Storage, Hydrogen Production- Non hydrogen Fuel Cells.

TOTAL: 45 PERIODS

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

CO1: Understand the configurations and performance of electric vehicle

CO2: Explain hybrid electric vehicle

CO3: Analyze the different types of electric propulsion systems

CO4: Distinguish different concept of energy storage and regenerative braking.

CO5: Explain the fuel cell technologies.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	1	-	2	-	2	-	-	2	2	1	3	-
CO2	3	-	1	-	3	-	2	-	-	2	2	1	3	-
CO3	3	-	1	-	2	-	2	-	-	2	2	1	3	-
CO4	3	-	1	-	2	-	2	-	-	2	2	1	3	-

CO5	3	-	1	-	-	-	2	-	-	2	2	1	3	-

TEXT BOOKS:

1. Mehrdad Ehsani, Yimin Gao, Stefano Longo Kambiz M. Ebrahimi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles", CRS Press, 2018.

2. Husain, Iqbal. Electric and Hybrid Vehicles: Design Fundamentals. United States, CRC Press, 2021.

REFERENCE BOOKS:

1. Iqbal Husain "Electric and Hybrid Vehicles: Design Fundamentals" CRC Press, 2011.

2. Seref Soylu "Electric Vehicles - The Benefits and Barriers" InTech Publishers, Croatia, 2011.

3. Aulice Scibioh M. and Viswanathan B "Fuel Cells – Principles and Applications" University Press, India, 2008.

WEB RESOURCES:

Hybrid Electric vehicle: https://archive.nptel.ac.in/courses/108/103/108103009/

EE606509-ENERGY STORAGE AND MANAGEMENT FOR ELECTRIC VEHICLES

Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To learn about the energy storage systems for electric vehicle
- To study the various techniques for battery electric management
- To study the various techniques for battery thermal management
- To study the basics of battery testing and recycling process
- To know the legal issues in battery charging systems and infrastructure

UNIT I ENERGY STORAGE DEVICES	**9**

Batteries: Fundamental principles- Technical Description – Electrical Performance – Environmental safety of Lead Acid Battery- Nickel based batteries- Sodium based batteries- Lithium based batteries – Li-ion & Li-poly- Metal Air Battery; other forms of Energy – Comparison - Battery parameters

UNIT II BATTERY ELECTRIC MANAGEMENT SYSTEM	9
High voltage Battery systems - Components of HV battery packs - Requirements of HV battery packs - Cell balancing, Types, causes, and effects of imbalances in battery cells- Balancing methods- battery state Estimation, and safety aspects of battery management systems for electric vehicles, State of Charge of batteries.	
UNIT III BATTERY THERMAL MANAGEMENT	**9**
Motivation for battery thermal management - Heat sources, sinks, and thermal balance- Design aspects of thermal management systems - Air-cooled systems - Dielectric liquid-based systems- Indirect liquid-cooled systems- Refrigerant-based systems- Thermoelectric elements- Phase change material- Operational aspects - Battery aging overview.	
UNIT IV BATTERY TESTING AND RECYCLING	**9**
Standards applicable to EVs- Testing procedures for EV batteries- Testing for battery life- Testing for battery safety- Future trends in battery testing- Battery recycling - General operational loop for EV battery saving - Recycling technologies - Lithium-Ion Battery Recycling Process- Sorting- Dismantling and separation Acid leaching - Recent developments	
UNIT V CHARGING INFRASTRUCTURE AND REGULATIONS	**9**
Mobility behavior and charging infrastructure- Driving behavior – Pause times – Parking Location - Classification of battery charging systems and infrastructure – Plug Types - Safety considerations during charging - Standards and regulations - Licensing regulations for electric vehicles: legal requirements regarding rechargeable energy storage systems – E Waste Management Rule 2018.	
	TOTAL: 45 PERIODS
COURSE OUTCOMES: At the end of the course, the student will be able to	
CO1: Understand the energy storage system.	
CO2: Select the Effective battery electric management system.	
CO3: Able to select suitable thermal management application for the Electric vehicle.	
CO4: List out the possible ways for testing and disposal of Battery.	
CO5: Illustrate the legal issues and the barriers on electric Vehicle charging systems	
CO-PO MAPPING	

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	

CO1	3	-	2	-	2	2	2	1	2	2	2	-	3	-
CO2	3	-	3	-	3	2	2	1	2	2	2	-	3	-
CO3	3	-	2	-	2	1	2	1	1	2	2	-	3	-
CO4	3	-	2	-	2	2	2	1	2	2	2	-	3	-
CO5	3	-	-	-	-	1	2	1	1	2	2	-	3	-

TEXT BOOKS:

1. James Marco, Quang Truong Dinh, Stefano Longo, Energy Storage and Management for Electric Vehicles. Switzerland, MDPI AG, 2020.

REFERENCE BOOKS:

1. Larminie, James, and John Lowry. Electric vehicle technology explained. John Wiley & Sons, 2012.

2. Link, Albert N., Alan C. O'Connor, and Troy J. Scott. Battery Technology for electric vehicles: Public science and private innovation. Routledge, 2015.

3.Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2011

4.Seref Soylu “Electric Vehicles - The Benefits and Barriers” InTech Publishers, Croatia, 2011

WEB RESOURCES:

Electric vehicle battery technology: https://elearn.nptel.ac.in/shop/nptel/electric-vehicles-and-renewable-energy/

EE606510-INTELLIGENT AND AUTONOMOUS VEHICLES						
Course Category: Program Core	**Course Type: Theory**		**L**	**T**	**P**	**C**
			3	**0**	**0**	**3**
COURSE OBJECTIVES:						

- To study the intelligent vision system used in Electric Vehicles Transportation.

UNIT I INTRODUCTION TO INTELLIGENT VISION SYSTEM	**9**

Vision Based Driver Assistance System- Non Contact ground velocity detecting Sensor, Road Surface Recognition Sensor-Vehicle Sensors for Electronic Toll Collection System-Components of a Vision Sensor System , Driver Assistance on Highways –Lane Recognition, Traffic Sign Recognition, Driver Assistance in Urban Traffic-Stereo Vision,

UNIT II VEHICLE INFORMATION SYSTEM AND INTELLIGENT TRANSPORTATION	**9**

Intelligent Transportation System (ITS) – Vision for ITS Communications, Multimedia communication in a car – Current ITS Communication Systems and Services-Vehicle to Vehicle and Road to Vehicle Communication Systems- Inter and Intra Vehicle Communication-VANETS-Devices-Optical Technologies and Millimeter Wave technologies	
UNIT III ADAPTIVE CONTROL TECHNIQUES FOR INTELLIGENT VEHICLES	**9**
Automatic Control Of Highway Traffic And Moving Vehicles- Adaptive Control Of Highway Traffic And Moving Vehicles- Adaptive Control –Gain Scheduling- Model Reference Adaptive Control- Self Tuning Adaptive Control System Model – System Identification Basics, Recursive Parameter Estimation, Estimator Initialization- Design Of Self-Tuning Controllers –Generalized Minimum Variance (GMV) Control, Pole Placement Control And Model Predictive Control.	
UNIT IV DECISIONAL ARCHITECTURES FOR AUTONOMOUS VEHICLES	**9**
Control Architectures And Motion Autonomy –Deliberative Architectures, Reactive Architectures, Hybrid Architectures-Overview Of Sharp Architecture, Models Of Vehicles-Concepts Of Sensor Based Maneuver, Reactive Trajectory-Following, Parallel Parking, Platooning-Main Approaches To Trajectory Planning, Non- Holonomic Path Planning.	
UNIT V AUTONOMOUS VEHICLE AND CASE STUDIES	**9**
DARPA Challenge Case Study- ARGO Prototype Vehicle- The Gold System-The inverse Perspective Mapping ,Lane Detection, Obstacle Detection, Vehicle Detection, Pedestrian Detection- Software systems architecture, Computational Performances- ARGO Prototype vehicle Hardware –Functionalities, Data acquisition System, Processing System and Control System	
TOTAL: 45 PERIODS	
COURSE OUTCOMES: At the end of the course, the student will be able to	
CO1: Explain the intelligent vision system used in Electric Vehicles Transportation.	
CO2: Understand the communication system used in Electric Vehicle Transportation	
CO3: Know the architecture of intelligent transportation system	
CO4: Understand the adaptive control techniques of an autonomous vehicle	
CO5: Narrate the successful autonomous vehicle projects	

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	-	1	2	-	2	2	2	2	2	-	3	2
CO2	3	1	-	-	3	-	2	2	2	2	2	-	3	2
CO3	3	1	-	1	2	-	2	2	1	2	2	-	3	2
CO4	3	11	-	-	2	-	2	2	2	2	2	-	3	2
CO5	3	11	-	-	2	-	2	2	1	2	2	-	3	2

TEXT BOOKS:

1. Ljubo Vlacic, Michel Parent and Fumio Harashima,"Intelligent Vehicle Technologies", Butterworth-Heinemann publications, Oxford, 2001-ISBN 0 7506 5093 1

2. Ronald K Jurgen, "Automotive Electronics Handbook", Automotive Electronics Series, SAE, USA, 1998.

REFERENCE BOOKS:

1. Nicu Bizon, Lucian D Ascalescu And Naser Mahdavit Abatabaei "Autonomous Vehicles Intelligent Transport Systems And Smart Technologies", Nova Publishers-2014–ISBN-978-1-63321-326-5

2. A. Mary Sowjanya, Allam Balaram, Imran Khan, Romil Rawat, Syed Imran Patel, Varshali Jaiswal, Autonomous Vehicles, Volume 1: Using Machine Intelligence. United Kingdom, Wiley, 2023.

WEB RESOURCES:

Autonomous vehicle control. https://www.cranfield.ac.uk/courses/taught/autonomous-vehicle-dynamics-and-control

STREAM 6 – ELECTRICAL AND COMPUTATIONAL SCIENCES

CS640206-OBJECT ORIENTED PROGRAMMING USING JAVA

Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To learn about Java features
- To understand Object Oriented Programming concepts and basic characteristics of Java
- To know the basic principles of inheritance and interfaces

- To develop Java applications with threads and package
- To define exceptions and use I/O streams

UNIT 1: INTRODUCTION	**9**

Fundamentals of Object-Oriented Programming - Java Features – Difference between Java and C - Java Environment - Overview of Java Language: Introduction - Simple Java Program - Java Program Structure – Java Tokens – Java statements – Implementing a Java program – Java Virtual Machine – Command line arguments – Constants, variables and Data Types – Operators and Expressions – Branching and Looping

UNIT 2: BASIC CONSTRUCTS	**9**

Class: Introduction – Defining a Class – Fields Declaration – Methods Declaration – Creating Objects – Accessing Class Members – Constructors – Method Overloading – Static Members – Nesting of Methods – Arrays, Strings and Vectors: Introduction – One-Dimensional Arrays – Creating an Array – Two-Dimensional Arrays – Strings

UNIT 3: INHERITANCE AND INTERFACES	**9**

Inheritance: Extending a class – Overriding methods – Final Variables and Methods – Final Classes – Finalizer Methods – Abstract Methods and Classes – Visibility Control - Interfaces: Multiple Inheritance: Introduction – Defining Interfaces – Extending Interfaces – Implementing Interfaces – Accessing Interface Variables

UNIT 4: PACKAGES AND MULTITHREADING	**9**

Packages: – Java API Packages – Using System Packages – Naming Conventions – Creating Packages – Accessing a Package – Using a Package – Adding a Class to a Package – Hiding Classes - Multithreaded Programming: Introduction – Life Cycle of a Thread – Creating Threads – Extending the Thread Class - Implementing the 'Runnable' Interface - Stopping and Blocking a Thread — Using Thread Methods

UNIT 5: EXCEPTION AND I/O HANDLING	**9**

Exception Handling: Introduction – Types of Errors – Exceptions – Syntax of Exception Handling Code – Multiple Catch Statements – Using Finally Statement – Throwing Our Own Exceptions - Input/output: Introduction – Concept of Streams – Stream Classes – Byte Stream Classes – Character Stream Classes – Handling Primitive Data Types - Simple input and output

TOTAL: 45 PERIODS

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

CO1: Understand to implement, compile, test and run Java program

CO2: Develop Java programs using OOP principles

CO3: Develop Java programs implementing the concepts of inheritance and interfaces

CO4: Develop multi-threaded and package Java applications

CO5:Build Java applications with exception handling and using I/O streams

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2			
CO1	1	2	2									2					
CO2	2	2									2						
CO3	1	2	1									2					
CO4	2	1									1	1					
CO5	1	2	2								2	1					

TEXT BOOKS:

1. E. Balagurusamy, “Programming with Java: A Primer”, Fourth Edition, First reprint, Tata McGraw Hill, Reprint 2011

REFERENCE BOOKS:

1. Herbert Schildt, “Java: A Beginner's Guide”, 4thEdition, Tata McGraw Hill, 2007
2. C. Xavier, “Java Programming: A Practical Approach”, Tata McGraw Hill, 2011
3. Paul Deitel & Harvey Deitel, “Java How to Program”, Eleventh Edition, Pearson Education Ltd. 2017

WEB RESOURCES:

1. OOPS Concepts in Java

https://www.mygreatlearning.com/blog/oops-concepts-in-java/

https://www.freecodecamp.org/news/object-oriented-programming-concepts-java/

CS630202-DATA STRUCTURE USING C++

Course Category: Program Elective	Course Type: : Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the basic concepts of OOPS and basic constructs in C++
- To learn how to define classes, objects, statements and constructors in C++
- To understand the concepts of operator overloading and inheritance in C++
- To understand the concepts of linear data structures and sorting

- To understand the basic concepts of related to operating systems and computer networks

UNIT 1: INTRODUCTION TO OOPS AND C++	**9**

Object oriented programming paradigm – Basic concepts of object oriented programming – Benefits of OOP – A simple C++ program - Basics of C++**:** Tokens – Keywords – Identifiers and constants – Basic data types - Declaration of variables – Operators in C++ – Scope resolution operator – Operator precedence.

UNIT 2: CONTROL STRUCTURES AND STATEMENTS IN C++	**9**

Control structures in C++: if statement – switch statement – do-while statement – while statement – else statement - for statement - Functions in C++: Introduction - The main function – Function prototyping – Call by reference – Return by reference – Inline functions - Method overloading – friend and virtual functions – Math library functions.

UNIT 3: BASIC OOPS CONCEPTS IN C++	**9**

Specifying a class – Defining member functions – A C++ program with class – Parameterized constructors – Multiple constructors in a class – Constructors with default arguments – Copy constructor – Destructors - Operator overloading – Inheritance - Single inheritance – Multilevel inheritance – Multiple inheritance – Hierarchical inheritance – Hybrid inheritance.

UNIT 4: BASIC DATA STRUCTURES AND SORTING	**9**

Algorithm – Analysis – List ADT – Stack ADT – Queue ADT – Priority Queue – Stack implementation – Basic operations on stack – Application of stack – Queue: Introduction – Definition of Queue –implementation of Queue – Operation on a Queue – Applications of Queue – Sorting : bubble sort-Insertion sort - Merge sort - Quick sort-Searching - hashing

UNIT 5: GRAPH AND TREES	**9**

Trees: Introduction – Tree – Basic elements of a tree – Binary tree – Representation of binary tree – Operations on binary tree – AVL Tcree – Operations on AVL Tree - Graph: Representation - Shortest path algorithm: Dijikstra's algorithm - Minimum spanning tree: Prim's Algorithm

TOTAL: 45 PERIODS

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

CO1: Understand the difference between object oriented programming and procedural oriented language and data types in C++

CO2: Implement C++ programs with features such as composition of objects, Polymorphism.

CO3: Implement C++ programs with features such as Operator overloading and inheritance

CO4: Choose an appropriate data structure for a particular problem

CO5:Simulate problems in the subjects like Operating system, Computer networks and also real world problems in C++

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	2	2								1	2		
CO2	2	1	1									1		
CO3	1	2	2								2	1		
CO4	2	1	1								1	2		
CO5	2	2	2									1		

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1. E.Balagurusamy, "Object Oriented Programming with C++", Fifth Edition, Tata McGraw Hill, 2011 (Unit I,II and III)

2. Mark Allen Weiss, "Data Structures and Algorithm Analysis in C++", Third edition, Pearson Education Asia, 2010. (Unit IV and V)

3. D.S.Malik, "Data Structures using C++", Second Edition, 2010.

REFERENCE BOOKS:

1.M.T. Somashekara, Programming In C++, PHI Pvt. Ltd., 2008

2.B.Trivedi, Programming with ANSI C++, Oxford University Press, 2007

3. Rajesh K. Shukla, "Data Structures using C & C++", 2019.

WEB RESOURCES:

1.https://www.edx.org/course/data-structures-algorithms-using-c

2.https://www.includehelp.com/c-programming-data-structure-examples.aspx

OPERATING SYSTEMS

Course Category: Program Elective	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:		
• To gain knowledge about various advanced techniques and concepts involved in operating systems • To incorporate knowledge to processes and threads • To know the concept of semaphore and deadlock • To study about the various storage strategies • To study about the concepts of I/O systems		
UNIT 1: OPERATING SYSTEMS OVERVIEW		**9**
Operating system – Main frame systems – Desktop systems – Multiprocessor systems – Distributed systems – Clustered systems – Real-time systems – Handheld systems – Operating System structures: System components – Operating system services - System calls – System programs – System structure		
UNIT 2: PROCESSES AND THREADS		**9**
Process: Process concept – Process scheduling – Operations on processes – Cooperating processes – Interprocess communication – Communication in client-server systems - Threads: Overview - Multithreading models – Threading issues – Pthreads - CPU Scheduling: Basic concepts - Scheduling criteria – Scheduling algorithms – Multiple-processor scheduling – Real time scheduling		
UNIT 3: PROCESS MANAGEMENT		**9**
Process synchronization: The critical-section problem – Synchronization hardware – Semaphores – Classic problems of synchronization – Critical regions – Monitors – Deadlocks: System model – Deadlock characterization – Methods for handling deadlocks – Recovery from deadlock		
UNIT 4: STORAGE MANAGEMENT		**9**
Memory Management: Background -Swapping – Contiguous memory allocation – Paging – Segmentation – Segmentation with paging - Virtual Memory: Background – Demand paging – Process creation – Page replacement – Allocation of frames – Thrashing		
UNIT 5: I/O SYSTEMS		**9**
File-system interface: File concept – Access methods – Directory structure – File-system mounting – File sharing - Protection – File-system implementation: Directory implementation – Allocation methods – Free-space management – Mass storage structure: Disk structure - Disk scheduling – Disk management – Swap-space management		

TOTAL: 30 PERIODS

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

CO1: Understand the fundamental concepts of operating system

CO2: Understand the concept of processes and threads scheduling

CO3: Analyze the various semaphores techniques and the deadlock handling mechanism

CO4: Analyze the different storage management strategies

CO5:Understand the concept of I/O systems

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	2						2		1	2		
CO2	1	2	1						1		2			
CO3	2	2	1						2		2	1		
CO4	2	1	2						1		1	2		
CO5	1	2	2						1		1	1		

1- low, 2 - medium, 3 - high, '-' no correlation

TEXT BOOKS:

1.Silberschatz, Galvin and Gagne, "Operating System Concepts", Eighth Edition, John Wiley & Sons Inc., Reprint 2011

2. Avi Silberschatz, Peter Baer Galvin, Greg Gagne, "Operating System Concepts", Eight Edition

3.Abraham Silberschatz, Peter Baer Galvin, Greg Gagne, "Operating System Concepts", Ninth Edition

REFERENCE BOOKS:

1.William Stallings, " Operating Systems: Internals and Design Principles" Seventh Edition, Pearson Education, 2011

2. H M Deital, P J Deital and D R Choffnes, "Operating Systems", Pearson Education, 2004.

3. Pramod Chandra P Bhatt, "An Introduction to Operating Systems : Concepts and Practice", PHI Learning Pvt. Ltd.,2010

WEB RESOURCES:

https://www.os-book.com/OS10/

https://drive.uqu.edu.sa/_/mskhayat/files/MySubjects/2017SS%20Operating%20Systems/Abraham%20Silberschatz-Operating%20System%20Concepts%20(9th,2012_12).pdf

EE606604-DATA ANALYSIS USING PYTHON FOR ELECTRICAL ENGINEERS		
Course Category: Program Elective	**Course Type: Theory**	**L T P C** **3 0 0 3**
COURSE OBJECTIVES:		
This course is designed to teach students how to analyze different types of data using Python. Students will learn how to prepare data for analysis, perform simple statistical analysis, create meaningful data visualizations and predict future trends from data.		
UNIT 1: INTRODUCTION		**9**
Python Fundamentals for Data Analysis Python data structures, Control statements, Functions, Object Oriented programming concepts using classes, objects and methods, Exception handling, Implementation of user-defined Modules and Package, File handling in python.		
UNIT 2: DATA ANALYSIS		**9**
Introduction to Data Understanding and Pre-processing Knowledge domains of Data Analysis, Understanding structured and unstructured data, Data Analysis process, Dataset generation, Importing Dataset: Importing and Exporting Data, Basic Insights from Datasets, Cleaning and Preparing the Data: Identify and Handle Missing Values.		
UNIT 3: DATA PROCESS		**9**
Data Processing and Visualization Data Formatting, Exploratory Data Analysis, Filtering and hierarchical indexing using Pandas. Data Visualization: Basic Visualization Tools, Specialized Visualization Tools, Sea-born Creating and Plotting Maps.		
UNIT 4: NUMPY AND SCIPY		**9**
Mathematical and Scientific applications for Data Analysis Numpy and Scipy Package, Understanding and creating N-dimensional arrays, Basic indexing and slicing, Boolean indexing, Fancy indexing, Universal functions, Data processing using arrays, File input and output with arrays.		
UNIT 5: MODEL DEVELOPMENT AND EVALUATION INTRODUCTION TO MACHINE LEARNING		**9**
Analysing Web Data Data wrangling, Web scrapping, Combing and merging data sets,		

Reshaping and pivoting, Data transformation, String Manipulation, case study for web scrapping. Model Development and Evaluation Introduction to machine learning-Supervised and Unsupervised Learning, Model development using Linear Regression, Model Visualization, Prediction and Decision Making, Model Evaluation: Over-fitting, Under-fitting and Model Selection.

TOTAL: 45 PERIODS

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

CO1: Explain about the architecture of different Programmable Logic devices.

CO2: Describe about the basic programming structure of VHDL.

CO3: Illustrate about Behavioural and Structural modelling of VHDL.

CO4: Describe about sequential modelling of VHDL.

CO5: Design and write the VHDL code for any applications.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2			
CO1	3	1	2	2	3				2	2	1	2	2	1			
CO2	3	1	2	2	3				2	2	1	2	2	1			
CO3	3	2	2	2	3				2	2	1	2	2	1			
CO4	3	2	2	2	3				2	2	1	2	3	1			
CO5	3	2	2	2	3				2	2	1	2	3	1			

TEXT BOOKS:

1. David Ascher and Mark Lutz, Learning Python, Publisher O'Reilly Media, 2018.

2 Reema Thareja, "Python Programming using Problem Solving approach", Oxford University press, 2016.

3. Wes Mckinney "Python for Data Analysis", First edition, Publisher O'Reilly Media, 2017.

REFERENCE BOOKS:

1 Allen Downey, Jeffrey Elkner, Chris Meyers,: Learning with Python, Dreamtech Press, 2020.

2. David Taieb , "Data Analysis with Python: A Modern Approach " 1st Edition, Packt Publishing, 2016.

WEB RESOURCES:

Data Analytics with Python

https://onlinecourses.nptel.ac.in/noc21_cs45/preview

EE606605-DATA MANAGEMENT FOR SMART GRID		
Course Category: Program Elective	**Course Type: Theory**	L: 3, T: 0, P: 0, C: 3

COURSE OBJECTIVES:

- To Study about Smart Grid technologies, different smart meters and advanced metering infrastructure.
- To know about the function of smart grid.
- To familiarize the power quality management issues in Smart Grid.
- To familiarize the high performance computing for Smart Grid applications
- To get familiarized with the communication networks for Smart Grid applications

UNIT 1: INTRODUCTION TO SMART GRID	**9**

Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, functions, opportunities, challenges and benefits, Difference between conventional & Smart Grid, Comparison of Micro grid and Smart grid, Present development & International policies in Smart Grid, Smart Grid Initiative for Power Distribution Utility in India – Case Study.

UNIT 2: SMART GRID TECHNOLOGIES	**9**

Technology Drivers, Smart Integration of energy resources, Smart substations, Substation Automation, Feeder Automation ,Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and control, Distribution systems: DMS, Volt/Var control, Fault Detection, Isolation and service restoration, Outage management, High-Efficiency Distribution Transformers, Phase Shifting Transformers, Plug in Hybrid Electric Vehicles (PHEV) – Grid to Vehicle and Vehicle to Grid charging concepts.

UNIT 3: SMART METERS AND ADVANCED METERING INFRASTRUCTURE	**9**

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

management and demand response programs, Demand pricing and Time of Use, Real Time Pricing, Peak Time Pricing.

UNIT 4: POWER QUALITY MANAGEMENT IN SMART GRID	**9**

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

UNIT 5: HIGH PERFORMANCE COMPUTING FOR SMART GRID APPLICATIONS	**9**

Architecture and Standards -Local Area Network (LAN), Home Area Network (HAN), Wide Area Network (WAN), NAN, Broadband over Power line (BPL), PLC, Zigbee, GSM, IP based Protocols, Basics of Web Service and CLOUD Computing, Cyber Security for Smart Grid.

TOTAL: 45 PERIODS

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

CO1: Relate with the smart resources, smart meters and other smart devices.

CO2: Explain the function of Smart Grid

CO3: Experiment the issues of Power Quality in Smart Grid

CO4: Analyze the performance of Smart Grid.

CO5: Recommend suitable communication networks for smart grid applications.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2		
CO1	3	2	2	2	3			1				2	2	2		
CO2	3	2	2	2	3			1	1			2	2	2		
CO3	3	2	3	3	3			1	1			2	2	2		
CO4	3	2	3	3	3	1		1	1		1	2	2	2		
CO5	3	2	3	3	3	1		1	1		1	2	2	2		

TEXT BOOKS:

1 Stuart Borlase ‘Smart Grid: Infrastructure, Technology and Solutions’, CRC Press 2012.

2.. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, ‘Smart Grid: Technology and Applications’, Wiley, 2012

REFERENCE BOOKS:

1. Mini S. Thomas, John D McDonald, 'Power System SCADA and Smart Grids', CRC Press, 2015

2. Kenneth C.Budka, Jayant G. Deshpande, Marina Thottan, 'Communication Networks for Smart Grids', Springer, 2014

WEB RESOURCES:

Introduction to Smart Grid

https://archive.nptel.ac.in/noc/courses/noc18/SEM2/noc18-ee42/

Introduction to Internet of Things

http://www.digimat.in/nptel/courses/video/106105166/L52.html

EE606606-COMMUNICATION AND DATA SECURITY IN ELECTRICAL ENGINEERING

Course Category: Program Elective	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To interpret the different building blocks of Communication network and its architecture.
- To identify and analyze error and flow control mechanisms in data link layer
- To analyze the performance of network layer and examine various routing protocols
- Compare various congestion control mechanisms and identify appropriate Transport layer protocol for real time applications
- Identify the suitable Application layer protocols for specific applications and its respective security mechanisms

UNIT 1: INTRODUCTION TO NETWORK COMPONENTS **9**

Components of network – Topologies – WAN / LAN – OSI – ISO layered Architecture – digital Modulation and demodulation techniques – Bit error rates – Line coding – Error correcting codes.

UNIT 2: DATA LINK LAYER **9**

Design issues – CRC technique and sliding window techniques – Performance analysis of sliding window techniques – Framing formats – Case Study – HDLC protocols – Medium

access control – CSMA / CD – Token ring and token bus – FDDI – Wireless Networks – Performance analysis of MAC protocols – Bridges.

UNIT 3: NETWORK LAYER	**9**

Circuit switching – packet switching – Design issues – IP addressing and IP datagram – Routers and gateways – Routing –Subnetting – CIDR – ICMP – ARP – RARP – basics of Ipv6 – QoS.

UNIT 4: TRANSPORT LAYER	**9**

TCP and UDP – Error handling and flow control – Congestion control – TCP Retransmission – Timeout – Socket Abstraction.

UNIT 5: APPLICATION SERVICES	**9**

Simple Mail Transfer Protocol (SMTP) – Secure File Transfer Protocols (SFTP), telnet, the World Wide Web (WWW), Hypertext Transfer Protocol (HTTP), Domain name service (DNS), Security, Multimedia applications, DHCP.

TOTAL: 45 PERIODS

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

CO1: Interpret the different building blocks of Communication network and its architecture.

CO2: Identify and analyze error and flow control mechanisms in data link layer

CO3: Analyze the performance of network layer and examine various routing protocols

CO4: Compare various congestion control mechanisms and identify appropriate Transport layer protocol for real time applications

CO5: Identify the suitable Application layer protocols for specific applications and its respective security mechanisms

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2			
CO1	3	2	2	1	3				2		1	3	2	2			
CO2	3	2	2	1	3				2		2	3	2	2			
CO3	3	2	2	2	3				2		2	3	2	2			
CO4	3	2	2	2	3				2		2	3	2	2			
CO5	3	2	2	2	3				2		2	3	3	2			

TEXT BOOKS:

1. Data Communications and Networking, Behrouz A. Forouzan, McGraw Hill Education, 5th Ed., 2012.

2. Advances in Data Computing, Communication and Security: Proceedings of I3CS2021. (2022). Singapore: Springer Nature Singapore.

REFERENCE BOOKS:

1. Larry Peterson and Bruce Davie, "Computer Networks: A Systems Approach", The Morgan Kaufmann Series, Elsevier, 5th Ed, 2011.

2. James F Kurose, "Computer Networking: A Top – Down Approach Featuring the Internet", Addison Wesley, 2nd Edition 2002.

WEB RESOURCES:

The Role of Electrical and Computer Engineers in Cybersecurity.
https://online.engineering.arizona.edu/news/electrical-computer-engineers-cybersecurity/

EE606607-COMMUNICATION PROTOCOLS: SECURITY AND PROTECTION FOR SMART GRIDS

Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To understand the various components in Industrial embedded.
- To understand the architecture and programming of ARM and ability to design, troubleshoot, and simulate assembly and C language programs

UNIT 1: OVERVIEW OF INDUSTRIAL EMBEDDED SYSTEMS **9**

Introduction to Embedded Systems - Case Study: Fuel Filling Station, ATM, Linear Weighing Machine - Identification of User Interfaces (Inputs and Outputs) - Identification of System Interfaces (Sensors and Actuators) – Role of Microcontroller – Development of Control Algorithm.

UNIT 2: ARM ARCHITECTURE AND PROGRAMMING **9**

Introduction to ARM7 Microcontroller - ARM7 LPC2138 - Power supply – Program

Memory – Data Memory – Clock Circuit – Reset Circuit – Programming Tool Chain – KEIL IDE - Simulation using Proteus – List of ARM Peripherals – Pin Configuration.

UNIT 3: ARM COMMUNICATION PROTOCOLS **9**

Embedded C programming – Accessing of Digital Inputs and Outputs – ADC, DAC Programming - Timer and their applications - Programming of interrupts - PWM Generation – I2C – SPI Communication - UART Communication – RS232, RS485, MODBUS – CAN Communication.

UNIT 4: ARM INTERFACING **9**

Interfacing with Industrial sensors – Temperature, Pressure, Level, Flow, Interfacing with Industrial actuators – Solenoid Valves, Induction machine using VFD Drive, Stepper motor using Stepper Drive, Heater element.

UNIT 5: CASE STUDIES **9**

Mini Project – Development of PID Temperature control unit with PC Interfacing.

TOTAL: 45 PERIODS

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

CO1: Understand the various components in Industrial embedded.

CO2: Apply the knowledge on fundamentals of communication protocols

CO3: Understand critical real – time issues involved in end product design with solutions

CO4: Solve critical real – time issues involved in end product design with solutions

CO5: Understand of controlling circuits and systems interfaced to a development board.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2		
CO1	3	1	1	2	3			1	2		1	2	2	2		
CO2	3	1	1	1	3			1	2		1	2	2	2		
CO3	3	2	2	2	3			1	2		1	2	3	2		
CO4	3	2	2	2	3			1	2		1	2	3	2		
CO5	3	2	2	2	3			2	2		1	2	3	2		

TEXT BOOKS:

1. Janaka Ekanayake, N. Jenkins, K. Liyanage, J. Wu, Akihiko Yokoyama, “Smart Grid: Technology and Applications”, Wiley, 2015.

2. Smart Grid Fundamentals of Design and Analysis, James Momoh, IEEE press, A John Wiley & Sons, Inc., Publication, 2011.

3. Jean Claude Sabonnadiere, Nouredine Hadjsaid, “Smart Grids”, Wiley Blackwell, 2015.

REFERENCE BOOKS:

1. Clark W. Gellings, “The Smart Grid: Enabling Energy Efficiency and Demand Response”, CRC Press, 2020.
2. Ali K., M.N. Marwali, Min Dai, “Integration of Green and Renewable Energy in Electric Power Systems”, Wiley, 2013.

WEB RESOURCES:

Smart Grid: Basics to Advanced Technologies - Course
https://onlinecourses.nptel.ac.in/noc23_ee60/preview

EE606608-PLC PROGRAMMING		
Course Category: Program Elective	**Course Type: Theory**	**L T P C** **3 0 0 3**

COURSE OBJECTIVES:

- To educate on design of signal conditioning circuits for various applications
- To Introduce signal transmission techniques and their design
- Study of components used in data acquisition systems interface techniques
- To educate on the components used in distributed control systems
- To introduce the communication buses used in automation industries.

UNIT 1: INTRODUCTION	**9**

Automation overview, Requirement of automation systems, Architecture of Industrial Automation system, Introduction of PLC and supervisory control and data acquisition (SCADA). Industrial bus systems: Modbus & Profibus.

UNIT 2: AUTOMATION COMPONENTS	**9**

Sensors for temperature, pressure, force, displacement, speed, flow, level, humidity and pH measurement. Actuators, process control valves, power electronics devices DIAC, TRIAC, power MOSFET and IGBT. Introduction of DC and AC servo drives for motion control.

UNIT 3: COMPUTER AIDED MEASUREMENT AND CONTROL SYSTEMS:	**9**

Role of computers in measurement and control, Elements of computer aided measurement and control, man-machine interface, computer aided process control hardware, process related interfaces, Communication and networking, Industrial communication systems, Data transfer techniques, Computer aided process control software, Computer based data acquisition system, Internet of things (IoT) for plant automation

UNIT 4: PROGRAMMABLE LOGIC CONTROLLERS **9**

Programmable controllers, Programmable logic controllers, Analog digital input and output modules, PLC programming, Ladder diagram, Sequential flow chart, PLC Communication and networking, PLC selection, PLC Installation, Advantage of using PLC for Industrial automation, Application of PLC to process control industries.

UNIT 5: DISTRIBUTED CONTROL SYSTEM **9**

Overview of DCS, DCS software configuration, DCS communication, DCS Supervisory Computer Tasks, DCS integration with PLC and Computers, Features of DCS, Advantages of DCS.

TOTAL: 45 PERIODS

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

CO1: Design a signal conditioning circuits for various application

CO2: Acquire a detail knowledge on data acquisition system interface and DSC system

CO3: Understand the basics and Importance of communication buses in applied automation Engineering

CO4: Acquire a detail knowledge on the components used in distributed control systems

CO5: Introduce the communication buses used in automation industries.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2			
CO1	3	2	2	2	3			1				2	2	2			
CO2	3	2	2	2	3			1	1			2	2	2			
CO3	3	2	3	3	3			1	1			2	2	2			
CO4	3	2	3	3	3	1		1	1		1	2	2	2			
CO5	3	2	3	3	3	1		1	1		1	2	2	2			

TEXT BOOKS:

1. Antonsen, T. M. (2020). PLC Controls with Structured Text (ST), V3: IEC 61131-3 and Best Practice ST Programming. Germany: BoD – Books on Demand – Dänemark.

2. Clark, N. (2020). PLC Programming Using RSLogix 5000: Understanding Ladder Logic and the Studio 5000 Platform. (n.p.): Amazon Digital Services LLC - KDP Print US.

REFERENCE BOOKS:

1. E.A.Parr, Newnes, "Industrial Control Handbook", 3rd Edition, New Delhi, 2000.
2. Gary Dunning, Thomson Delmar, "Programmable Logic Controller", Ceneage Learning, 3rd Edition, 2005.
3. C D Johnson, "Process Control Instrumentation Technology", Prentice Hall India, 8th Edition, 2006.

WEB RESOURCES:

Introduction to Industrial Automation and Control
https://nptel.ac.in/courses/108105063

EE606609-MACHINE LEARNING

Course Category: Program Elective	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the need for machine learning for various problem solving
- To study the various supervised, semi-supervised and unsupervised learning algorithms in machine learning
- To understand the latest trends in machine learning
- To design appropriate machine learning algorithms for problem solving

UNIT 1: INTRODUCTION **9**

Learning Problems – Perspectives and Issues – Concept Learning – Version Spaces and Candidate Eliminations – Inductive bias – Decision Tree learning – Representation – Algorithm – Heuristic Space Search.

UNIT 2: NEURAL NETWORKS AND GENETIC ALGORITHMS **9**

Neural Network Representation – Problems – Perceptrons – Multilayer Networks and Back Propagation Algorithms – Advanced Topics – Genetic Algorithms – Hypothesis Space Search – Genetic Programming – Models of Evaluation and Learning.

UNIT 3: BAYESIAN AND COMPUTATIONAL LEARNING	9

Bayes Theorem – Concept Learning – Maximum Likelihood – Minimum Description Length Principle – Bayes Optimal Classifier – Gibbs Algorithm – Naïve Bayes Classifier – Bayesian Belief Network – EM Algorithm – Probability Learning – Sample Complexity – Finite and Infinite Hypothesis Spaces – Mistake Bound Model.

UNIT 4: INSTANT BASED LEARNING	9

K- Nearest Neighbour Learning – Locally weighted Regression – Radial Basis Functions – Case Based Learning.

UNIT 5: ADVANCED LEARNING	9

Learning Sets of Rules – Sequential Covering Algorithm – Learning Rule Set – First Order Rules – Sets of First Order Rules – Induction on Inverted Deduction – Inverting Resolution – Analytical Learning – Perfect Domain Theories – Explanation Base Learning – FOCL Algorithm – Reinforcement Learning – Task – Q-Learning – Temporal Difference Learning

TOTAL: 45 PERIODS

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

CO1: Differentiate between supervised, unsupervised, semi-supervised machine learning approaches

CO2: Discuss the decision tree algorithm and identity and overcome the problem of overfitting

CO3: Discuss and apply the back propagation algorithm and genetic algorithms to various problems

CO4: Apply the Bayesian concepts to machine learning

CO5: Analyse and suggest appropriate machine learning approaches for various types of problems

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2		
CO1	3	2	2	2	3			1				2	2	2		
CO2	3	2	3	3	3				1			2	2	2		
CO3	3	2	3	3	3				1			2	2	2		
CO4	3	2	3	3	3	1			2		1	2	2	2		
CO5	3	2	3	3	3	1		1	1		1	2	2	2		

TEXT BOOKS:

1. Tom M. Mitchell, ―Machine Learning, McGraw-Hill Education (India) Private Limited, 2013.

REFERENCE BOOKS:

1. Ethem Alpaydin, ―Introduction to Machine Learning (Adaptive Computation and Machine Learning), The MIT Press 2004.
2. Stephen Marsland, ―Machine Learning: An Algorithmic Perspective, CRC Press, 2009.

WEB RESOURCES:

Introduction to Machine Learning
https://nptel.ac.in/courses/106106139

EE606610-OPTIMIZATION STUDIES IN ELECTRICAL SYSTEMS

Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To model and solve problems using linear and non-linear programming.
- To identify the job sequence to minimize the total cost.
- To solve decision making problems.
- To apply game theory for solving problems in engineering and technology.
- To design mathematical models as networks for some real time situations.

UNIT 1: LINEAR AND NON-LINEAR PROGRAMMING PROBLEM **9**

Mathematical formulation of LPP – Graphical solution of LPP – General NLPP – Constrained optimization with equality and inequality constraints.

UNIT 2: SEQUENCING MODELS **9**

Sequencing problems – Assumptions in sequencing problems – Processing n jobs through one machine - Processing n jobs through two machines - Processing two jobs through m machines – Processing of n jobs through m machine - Problems related to sequencing.

UNIT 3: DECISION THEORY **9**

Decision making problem – Decision making environment – Decisions under uncertainty

– Decisions under risk – Decision tree analysis – Decision making with utilities.

UNIT 4: GAME THEORY **9**

Theory of games – Characteristics of games – Game models – Rules for game theory – Mixed strategies – n-person zero sum games – Limitations of game theory.

UNIT 5: NETWORK SCHEDULING BY PERT/CPM **9**

Rules for network construction – Critical path analysis – Probability considerations in PERT – Distinction between PERT and CPM – Resource analysis in network scheduling: Time-cost optimization algorithm.

TOTAL: 45 PERIODS

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

CO1: Solve linear and non-linear programming problems.

CO2: Model the n jobs through m machines with minimal cost.

CO3: Optimize the decisions using trees.

CO4: Solve n-person zero sum games.

CO5: Apply the techniques of minimizing the project duration and cost.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2			
CO1	3	1	1	2	3			1	2		1	2	2	2			
CO2	3	1	1	1	3			1	2		1	2	2	2			
CO3	3	2	2	2	3			1	2		1	2	3	2			
CO4	3	2	2	2	3			1	2		1	2	3	2			
CO5	3	2	2	2	3			2	2		1	2	3	2			

TEXT BOOKS:

1. Nature Inspired Optimization for Electrical Power System. Germany: Springer Nature Singapore, 2020.

2. Optimization of Power System Problems: Methods, Algorithms and MATLAB Codes, Germany: Springer International Publishing, 2020.

REFERENCE BOOKS:

1. Prem Kumar Gupta and Hira D.S., "Operations Research", 6th Edition, S.Chand & Company Ltd, 2013.

2. Taha H.A., "Operations Research", 9th Edition, Pearson India Education, 2016.

3. Sharma J.K., "Operations Research Theory and Applications", 5th Edition, Macmillan,

2013

4. Kanti Swarup, Gupta P.K and Man Mohan, "Operation Research", 16th Edition, Sultan Chand & sons, 2014

WEB RESOURCES:

Electrical Engineering - Optimal Control

https://archive.nptel.ac.in/courses/108/105/108105019/

STREAM 7 – DIVERSIFIED COURSES

EE606701- HYBRID ENERGY TECHNOLOGY

Course Category: Program Elective	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To provide knowledge about different types of hybrid energy systems.
- To analyze the various electrical Generators used for the Wind Energy Conversion Systems.
- To design the power converters used in SPV Systems.

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

Hybrid Energy Systems – Need for Hybrid Energy Systems – Solar-Wind-Fuel Cell-Diesel, Wind, Biomass-Diesel, Micro Hydel - PV, Ocean and geyser energy - Classification of Hybrid Energy systems – Importance of Hybrid Energy systems – Advantages and Disadvantages - Environmental aspects of renewable energy - Impacts of renewable energy generation on the environment - Present Indian and international energy scenario of conventional and RE sources - Ocean energy, Hydel Energy - Wind Energy, Biomass energy, Hydrogen energy - Solar Photovoltaic (PV) and Fuel cells: Operating principles and characteristics

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

Review of reference theory fundamentals –Construction, Principle of operation and

analysis: Squirrel Cage Induction Generator (SCIG), Doubly Fed Induction Generator (DFIG) - Permanent Magnet Synchronous Generator (PMSG).

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

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

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

Introduction to Power Converters – Stand-alone Converters -AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters - Bi-Directional Converters - Grid-Interactive Inverters - Matrix converter – Merits and Limitations.

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

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

TOTAL: 45 PERIODS

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

CO1: Analyze the impacts of hybrid energy technologies on the environment and demonstrate them to harness electrical power

CO2: Select a suitable Electrical machine for Wind Energy Conversion Systems and simulate wind energy conversion system

CO3: Design the power converters such as AC-DC, DC-DC, and AC-AC converters for SPV systems.

CO4: Analyze the power converters such as AC-DC, DC-DC, and AC-AC converters for Hybrid energy systems.

CO5: Interpret the hybrid renewable energy systems.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2

CO1	3	3	2	2	1	-	-	-	-	3		3	3	3
CO2	3	3	2	2	1	-	-	-	-	3		3	3	3
CO3	3	2	2	2	1	-	-	-	-	3		3	3	3
CO4	3	2	2	2	1	-	-	-	-	3		3	3	3
CO5	3	2	2	2	1	-	-	-	-	3		3	3	3

TEXT BOOKS:

1. Md. Rabiul Islam, Md. Rakibuzzaman Shah, Mohd Hasan Ali, "Emerging Power Converters for Renewable Energy and Electric Vehicles", CRC Press, First Edison, 2021

2. Hybrid Renewable Energy Systems and Micro grids. Netherlands: Elsevier Science, 2020.

3. Hybrid Energy System Models. Netherlands: Elsevier Science, 2020.

REFERENCE BOOKS:

1. Hybrid Renewable Energy Systems, United States: Wiley, 2021.

2. Kircicek, Y., Aktas, A. Solar Hybrid Systems: Design and Application. United States: Elsevier Science, 2021

3 Luo, Y., Shi, Y., Cai, N. Hybrid Systems and Multi-energy Networks for the Future Energy Internet. Netherlands: Elsevier Science, 2020.

WEB RESOURCES

1. Hybrid Energy System. https://www.sciencedirect.com/topics/engineering/hybrid-energy-system

2. Wind-Energy-Conversion-System

https://www.sciencedirect.com/topics/engineering/wind-energy-conversion-system

3. Modeling and Performance Analysis of Solar PV system

https://www.academia.edu/35619294/Modeling_and_Performance_Analysis_of_Solar_PV

EE606702-ENERGY EFFICIENT BUILDINGS

Course Category: Program Elective	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To impart knowledge on impact of solar radiation in buildings.

To study the concept of indoor air quality.

To design, construction and operation of energy efficient buildings.

To understand significance of green buildings and its operation.

UNIT I INTRODUCTION	**9**

The sun-earth relationship - Energy balance on the earth's surface - climate, wind, solar radiation and solar temperature - sun shading and solar radiation on surfaces - Energy impact on the shape and orientation of buildings - Thermal properties of building materials - Technology Roadmap on Energy efficient Buildings.

UNIT II ENERGY EFFICIENT TECHNOLOGIES	**9**

Passive cooling and day lighting - active solar and photovoltaic building energy analysis methods - building energy efficiency standards - different lighting technologies - Energy conservation in pumps, fans and blowers - heat rejection equipment - energy efficient motors and insulation - Energy Efficiency in Residential and Commercial Buildings.

UNIT III ENVIRONMENTAL COMPONENTS INSIDE BUILDING	**9**

Psychometric - comfort conditions - thermal comfort - ventilation and air quality - air conditioning requirement - visual perception - auditory requirement - illumination requirement - choice of lighting - lighting standards - control of lighting - lighting economics and aesthetics - energy saving - impacts of lighting efficiency - electronic ballast - Ventilation – Requirements – Minimum standards for ventilation – Ventilation Design – Energy conservation in ventilating systems

UNIT IV ENERGY TRANSFER IN BUILDINGS	**9**

Concepts of energy efficient buildings - Energy efficient HVAC systems - Heating and Cooling Equipment - Building’s energy balance accounting for solar energy gain – Heat losses - Internal heat sources - Study of climate and its influence in building design for energy requirement - Low energy and zero energy buildings.

UNIT V GREEN BUILDINGS	**9**

Ecological sustainable design - Barriers to green buildings - green building rating tools - material selection - embodied energy - operating energy - facade systems – transportation - water treatment systems - water efficiency - building economics - LEED and IGBC codes.

TOTAL: 45 PERIODS

COURSE OUTCOMES: Upon the successful completion of the course, students will be

able to

CO1: Describe the familiar about basic concepts of energy efficient buildings.

CO2: Understand the operation of various energy efficient technologies.

CO3: Know about the different components inside building environment.

CO4: Calculate the different energy transfer in buildings.

CO5: Understand the concept of green buildings and codes.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	1	3	-	-	1	-	3	-	1	3	-
CO2	3	3	2	1	3	-	-	1	-	3	-	1	3	-
CO3	3	2	2	1	3	-	-	1	-	3	-	1	3	-
CO4	3	2	2	1	3	-	-	1	-	3	-	1	3	-
CO5	3	2	2	1	3	-	-	1	-	3	-	1	3	-

TEXT BOOKS:

1. Energy Efficiency in Buildings: Both New and Rehabilitated, Switzerland: MDPI AG, 2020.

2. Sustainability Through Energy-Efficient Buildings. United Kingdom: Taylor & Francis Group, 2020.

3. Handbook of Energy Efficiency in Buildings: A Life Cycle Approach, Netherlands: Elsevier Science, 2018.

REFERENCE BOOK:

1. E. H. Y. Energy Efficient Buildings. Croatia: IntechOpen, 2017.

2. Krarti, Moncef. Energy-Efficient Electrical Systems for Buildings. United States: CRC Press, 2017.

WEB RESOURCES:

- Bureau of Energy Efficiency http://www.bee-india.nic.in
- International Energy Agency http://www.iea.org
- Sustainable Development Goals http://www.unep.org

EE606703-BLUETOOTH TECHNOLOGY					
Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:		
• To provide an insight into the bluetooth technology • To familiarize with the steps required for bluetooth radio and networking • To design connection establishment procedure • To understand about the hardware for bluetooth implementation • To design bluetooth communication for different applications		
UNIT 1: INTRODUCTION		**9**
Introduction to Wireless technologies: WAP services, serial and parallel Communication, Asynchronous and synchronous communication, EDM, TFM, Spread spectrum technology. Introduction to Bluetooth: Specification, core protocols, cable replacement protocol.		
UNIT 2:BLUETOOTH RADIO AND NETWORKING		**9**
Bluetooth Radio: Type of Antenna, Antenna Parameters, Frequency hopping Bluetooth Networking: Wireless networking, Wireless network types, devices roles and states, adhoc network, scatter net.		
UNIT 3:CONNECTION ESTABLISHMENT PROCEDURE		**9**
Connection establishment procedure, notable aspects of connection establishment, Mode of connection, Bluetooth Security, Security architecture, Security level of services, profile and usage model: Generic access profile(GAP), SDA, serial profile, Secondary Bluetooth profile.		
UNIT 4:HARDWARE		**9**
Hardware: Bluetooth implementation, Baseband overview, packet format, Transmission buffers, Protocol implementation: link manager protocol, logical link control Adaptation protocol, Host control interface, protocol interaction with layers		
UNIT 5: APPLICATIONS.		**9**
Programming with Java: Java Programming, J2ME architecture, Javax, Bluetooth package interface, classes, exceptions, Javax. obex package: interfaces, classes, Bluetooth services overview of IRDA, Home RF, Wireless LANs, JINI.		
		TOTAL: 45 PERIODS
COURSE OUTCOMES: At the end of the course, the student will be able to		
CO1: Understand the concept of bluetooth technology.		
CO2: Analyse bluetooth radio and networking.		
CO3: Understand connection establishment procedure.		
CO4: Get knowledge about hardware required for bluetooth technology.		

CO5: Design a bluetooth communication for different applications.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	3	2	2	2	2	2				1		
CO2	3	3	2	2	2								2	2
CO3	2	3	2	3	2								3	2
CO4	2	2	2	3	3								3	3
CO5	2	3	3	2	2	2	2				2	1		

TEXT BOOKS:

1White, Erica. Bluetooth: The Everything Guide to Bluetooth Technology. United States: Lulu.com, 2015.

2.Rezola, Ainhoa, Sevillano, JuanF.., Berenguer, Roc., delRio, David., Velez, Igone. Digitally Assisted, Fully Integrated, Wideband Transmitters for High-Speed Millimeter-Wave Wireless Communication Links. Germany: Springer International Publishing, 2018.

REFERENCE BOOKS:

1 Advances in Antenna, Signal Processing, and Microelectronics Engineering. United Kingdom: Apple Academic Press, 2021.

2. Pfleeger, Shari Lawrence, Margulies, Jonathan, Pfleeger, Charles P. Security in Computing. India: Pearson India Education Services, 2018.

WEB RESOURCES:

1 - Introduction to Bluetooth

https://www.youtube.com/watch?v=j5jksfno5OU

2.Bluetooth low energy

https://www.youtube.com/watch?v=zwUk1jjEoZk

EE606704-DEEP LEARNING

Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To understand the basic ideas and principles of Neural Networks
- To understand the basic concepts of Big Data and Statistical Data Analysis
- To familiarize the student with The Image Processing facilities like Tensorflow and Keras

- To appreciate the use of Deep Learning Applications
- To understand and implement Deep Learning Architectures

UNIT 1: BASICS OF NEURAL NETWORKS	**9**

Basic concept of Neurons – Perceptron Algorithm – Feed Forward and Back Propagation Networks

UNIT 2: INTRODUCTION TO DEEP LEARNING	**9**

Feed Forward Neural Networks – Gradient Descent – Back Propagation Algorithm – Vanishing Gradient problem – Mitigation – RelU Heuristics for Avoiding Bad Local Minima – Heuristics for Faster Training – Nestors Accelerated Gradient Descent – Regularization – Dropout

UNIT 3: CONVOLUTIONAL NEURAL NETWORKS	**9**

CNN Architectures – Convolution – Pooling Layers – Transfer Learning – Image Classification using Transfer Learning.

UNIT 4: MORE DEEP LEARNING ARCHITECTURES	**9**

LSTM, GRU, Encoder/Decoder Architectures – Autoencoders – Standard- Sparse – Denoising – Contractive- Variational Autoencoders – Adversarial Generative Networks – Autoencoder and DBM

UNIT 5: APPLICATIONS	**9**

Image Segmentation – Object Detection – Automatic Image Captioning – Image generation with Generative Adversarial Networks – Video to Text with LSTM Models – Attention Models for Computer Vision – Case Study: Named Entity Recognition – Opinion Mining using Recurrent Neural Networks – Parsing and Sentiment Analysis using Recursive Neural Networks – Sentence Classification using Convolutional Neural Networks – Dialogue Generation with LSTMs

TOTAL: 45 PERIODS

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

CO1: To get familiar with the use of TensorFlow/Keras in Deep Learning Applications.

CO2: To design and implement Deep Learning Applications.

CO3: Critically Analyse Different Deep Learning Models in Image Related Projects.

CO4: To design and implement Convolutional Neural Networks.

CO5: To know about applications of Deep Learning in NLP and Image Processing.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2

CO1	2	3	3	2	2	2	2	2				1		
CO2	3	2		2	2								2	2
CO3	2	3	3	2	2		2			3	2		3	2
CO4	2	2	3	3	3				1				3	3
CO5	2	3	3	2	2	2	2				2	1		

TEXT BOOKS:

1. Ian Good Fellow, Yoshua Bengio, Aaron Courville, "Deep Learning", MIT Press, 2017.
2. Francois Chollet, "Deep Learning with Python", Manning Publications, 2018.
3. Phil Kim, "Matlab Deep Learning: With Machine Learning, Neural Networks and Artificial Intelligence", Apress , 2017

REFERENCE BOOKS:

1. Ragav Venkatesan, Baoxin Li, "Convolutional Neural Networks in Visual Computing", CRC Press, 2018.
2. Navin Kumar Manaswi, "Deep Learning with Applications Using Python", Apress, 2018.
3. Joshua F. Wiley, "R Deep Learning Essentials", Packt Publications, 2016

WEB RESOURCES:

Deep Learning. https://nptel.ac.in/courses/106106184

EE606705-EDGE COMPUTING

Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To study the main concepts, key technologies, strengths, and limitations of edge computing and the possible applications for state-of-the-art edge computing
- To learn the architecture and infrastructure of edge computing

UNIT 1: INTRODUCTION **9**

History of Centralized and Distributed Computing - Overview of Distributed Computing, Cluster computing, Grid computing. Technologies for Network based systems- System models for Distributed and cloud computing- Software environments for distributed systems and clouds

UNIT 2:EDGE RESOURCES **9**

Introduction to Edge Computing- issues and challenges - Properties - Characteristics -

Service models, Deployment models. Cloud resources: Network and API - Virtual and Physical computational resources- Data-storage. Virtualization concepts - Types of Virtualization-Introduction to Various Hypervisors - High Availability (HA)/Disaster Recovery (DR) using Virtualization, Moving VMs.

UNIT 3:NETWORKS AND SERVICES **9**

Service models - Infrastructure as a Service (IaaS) - Resource Virtualization: Server, Storage, and Network - Case studies. Platform as a Service (PaaS) - Cloud platform & Management: Computation, Storage - Case studies. Software as a Service (SaaS) - Web services - Web 2.0 - Web OS - Case studies - Anything as a service (XaaS).

UNIT 4:PROGRAMMING **9**

Programming and Software Environments - Parallel and Distributed Programming paradigms - Programming on Amazon AWS and Microsoft Azure - Programming support of Google App Engine - Emerging Cloud software Environment.

UNIT 5 STANDARDS AND PRIVACY **9**

Cloud Access: authentication, authorization and accounting - Cloud Provenance and meta-data -Cloud Reliability and fault-tolerance - Edge Security, privacy, policy and compliance-Edge federation, interoperability and standards.

TOTAL: 45 PERIODS

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

CO1: Articulate the main concepts, key technologies, strengths, and limitations of edge computing and the possible applications for state-of-the-art edge computing

CO2: Identify the architecture and infrastructure of edge computing

CO3: Analyse the structures of SaaS, PaaS, IaaS, public cloud, private cloud, hybrid cloud, etc.

CO4: Understand the programming and Software Environments

CO5: Understand the core issues of edge computing such as security, privacy, and interoperability.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	2	2								3	2
CO2	3	2	3	2	3				3	2			2	2
CO3	3	3	2	2	2		3	2	2	2		3	2	
CO4	2	2	3	3	3		2	2				2	2	
CO5	2	3	2	2	2									

TEXT BOOKS:
1. Dharani, D, Kumari, K. Anitha, Sadasivam, G. Sudha, Niranjanamurthy, M. Edge Computing: Fundamentals, Advances and Applications. United States: CRC Press, 2021.
2. Fog and Edge Computing: Principles and Paradigms. United States: Wiley, 2019.
REFERENCE BOOKS:
1. Secure Edge Computing: Applications, Techniques and Challenges. United States: CRC Press, 2021.
2. Edge Computing: From Hype to Reality. Germany: Springer International Publishing, 2018.
WEB RESOURCES:
1 Evolution and Future of Cloud & Edge Computing https://www.youtube.com/watch?v=rifFwHPlOrs
2.Cloud, edge and fog computing for IoT https://www.youtube.com/watch?v=x13NRw4uMuI

EE606706-FUZZY SYSTEMS AND ITS APPLICATIONS		
Course Category: Program Elective	**Course Type: Theory**	**L T P C** **3 0 0 3**
COURSE OBJECTIVES:		
• To explain the basics of fuzzy Sets. • To describe fuzzy Numbers and operations on fuzzy numbers. • To apply defuzzification and fuzzification in sets. • To define various relations in fuzzy setts • To solve problems using Fuzzy Decision Making		
UNIT I INTRODUCTION ABOUT FUZZY SET THEORY		**9**
Introduction- Uncertainty-Imprecision and Vagueness-Fuzzy systems- Brief history of Fuzzy logic- Foundation of Fuzzy Theory- Fuzzy Sets and Systems- Representations of fuzzy sets - Extension principle for fuzzy sets – Operations of fuzzy sets – Types of operations – Fuzzy complements.		

UNIT II FUZZY NUMBERS AND OPERATIONS	9
Fuzzy Systems in Commercial Products- Research Fields in Fuzzy Theory,-Classical sets and Fuzzy sets- Classical Relations, Fuzzy relations, Membership Functions, Fuzzy to crisp conversions-Fuzzy arithmetic – Fuzzy numbers - Linguistic variables – Arithmetic operations on intervals – Arithmetic operations on fuzzy numbers – Fuzzy equations.	
UNIT III FUZZIFICATION AND DEFUZZIFICATION	**9**
Fuzzy arithmetic- Numbers-Vectors and the extension principle- Classical logic and Fuzzy logic-Mathematical background of Fuzzy Systems- Classical (Crisp) vs- Fuzzy sets-Representation of Fuzzy sets-Types of Membership Functions- Features of the membership function – Various forms – Fuzzification – Defuzzification to crisp sets – α-cut for fuzzy relations – Defuzzification to scalars	
UNIT IV FUZZY RELATIONS	**9**
Basic Concepts (support, singleton, height, a cut projections)- Fuzzy set operations- Sand T Norms, Properties of Fuzzy sets, Sets as Points in Hypercube-Cartesian Product-Crisp and Fuzzy Relations-Examples-Linguistic variables and hedges-Membership function design. Basic Principles of Inference in Fuzzy Logic Fuzzy IFTHEN Rules, Canonical Form- Fuzzy Systems-Fuzzy relations – Crisp versus fuzzy relations - Binary fuzzy relations – Binary relations on a single set - Fuzzy equivalence relations – Fuzzy compatibility relations.	
UNIT V FUZZY DECISION MAKING	**9**
Approximate Reasoning- Forms of Fuzzy Implication- Fuzzy Inference Engines- Graphical Techniques of Inference-Fuzzifications/Defuzzification-Fuzzy System Design and its Elements-Design options-Fuzzy Events- Fuzzy Measures-Possibility Distributions as Fuzzy Sets, Possibility vs- Probability-Fuzzy Systems as Universal Approximations-Additive Fuzzy Systems (standard additive model).Fuzzy decision making – Individual decision making – Militiaperson decision making – Multicriteria decision making – Fuzzy ranking methods – Fuzzy linear programming.	
TOTAL: 45 PERIODS	
COURSE OUTCOMES: At the end of the course, the student will be able to	
CO1: Understand the basics of Fuzzy system.	
CO2: Compute Fuzzy numbers and operations.	

CO3: Analyze the performance of Fuzzification and Defuzzification.

CO4: Analyze the performance of Fuzzy relation.

CO5: Describe the performance analysis Fuzzy decision making.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	1	2	2	-	1	2	1	3	3	1
CO2	3	3	2	2	1	2	2	-	1	2	1	3	3	1
CO3	3	2	2	2	1	2	2	-	1	2	1	3	3	1
CO4	3	2	2	2	1	2	2	-	1	2	1	3	3	1
CO5	3	2	2	2	1	2	2	-	1	2	1	3	3	1

TEXT BOOKS:

1. Fuzzy Systems: Theory and Applications. (2022). United Kingdom: IntechOpen.

2. Modern Fuzzy Control Systems and Its Applications. (2017). Croatia: IntechOpen.

3. Fuzzy Sets, Fuzzy Logic and Their Applications, MDPI AG, 2020.

REFERENCE BOOKS:

1. Ganesh M., “Introduction to Fuzzy sets and Fuzzy logic”, Prentice Hall of India, 2006.

2. Timothy J. Ross, “Fuzzy Logic with Engineering Applications”, 3rd Edition, Wiley Student Edition, 2010.

3. Zimmermann H.J., “Fuzzy Set Theory and its Applications”, Springer, 2013

WEB RESOURCES:

1. Fuzzy Sets, Logic and Systems & Applications
https://onlinecourses.nptel.ac.in/noc20_ee03/preview
2. Fuzzy Logic and Neural Networks
https://onlinecourses.nptel.ac.in/noc20_ge09/preview

EE606707-MUNICIPAL SOLID WASTE MANAGEMENT (NPTEL)

Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

ABOUT THE COURSE

The problems affiliated with solid waste management (SWM) in today’s sprawling civilized and urbanized society are intricate because of the quantity and varied nature of wastes, the funding restriction for public disposal, interference of technology (energy and

raw materials), and complex infrastructure development network in urban cities. As a result, if SWM is to achieve in consummate approach, the fundamentals aspects need to be identified. Thus, there is dire need to group the activities from the generation to the disposal point. The six different functional elements (generation, handing and separations, storage and processing at source, collection, the transformation of wastes, transfer and transport, and final disposal) for the engineering comparison and treatment need to be understood in detail. The understanding of the functional element is important because it helps in evaluating the impacts of projected changes and technological developments. Solid waste management is an essential part of every society, but it is also one of the most neglected one. An in-depth understanding of the subject is required to tackle the current solid waste management crisis effectively. This course attempts to familiarize various steps involved in solid waste management.

INDUSTRIES SUPPORT : Synergy waste management Pvt Ltd, UPL Environmental Engineers Pvt Ltd, Green power systems, A2Z group, Timarpu-Okhla waste management pvt ltd, Ramky Enviro Engineers Limited

Course Layout

Week 1: Evolution of Solid Waste Management

Week 2: Sources/Types and Characteristics of Solid Waste

Week 3: Generation of Solid Waste

Week 4: Waste Handling, Separation, storage, and Processing

Week 5: Collection of Solid Waste

Week 6: Transfer and Transport

Week 7: Separation and processing of Solid Waste

Week 8: Chemical Transformation (combustion/incineration)

Week 9: Biological Treatment (Composting)

Week 10: Biological Treatment (Anaerobic Digestion)

Week 11: Disposal of Solid Waste

Week 12: ISWM and legistlation

Books and References

1.Christensen, H. T., Solid Waste Technology & Management, Wiley, 2010, Volume 1 & 2

2.Haug, T. R., The Practical Handbook of COMPOST ENGINEERING, Lewis Publishers, 1993

3.Reinhart, R. D. and Townsend, G. T., Landfill Bioreactor Design & Operation, CRC Press, 1997, 1st Edition
4.Tchobanoglous, G. and Kreith, F., HANDBOOK OF SOLID WASTE MANAGEMENT, McGraw Hill, 2002, 2nd Edition
5.Tchobanoglous, G., Theisen and Vigil, Integrated Solid Waste Management: Engineering Principles and Management Issues, McGraw Hill, 1993.

WEB LINK:

1. Municipal Solid Waste Management.
https://onlinecourses.nptel.ac.in/noc20_ce56/preview

EE606708-AUGMENTED REALITY					
Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To study the concept of augmented reality
- To understand the benefits of AR.
- To learn how to incorporate the Geo-location with AR

UNIT 1: INTRODUCTION TO AUGMENTED REALITY **9**

Augmented Reality History-Definition of Augmented Reality- Augmented Reality features - Mixed Reality Continuum-MAR Market , Actors and Value Chain- MAR System Architecture – mobile AR for android and iOS-Application vs. Browser.

UNIT 2:AUGMENTED REALITY CONCEPTS AND HARDWARE **9**

Two-Step Process of Augmented Reality Applications- Augmented Reality Hardware- Sensor- Roles of Sensors- Tracking- processor- Processor System Architectures -display- Stationary visual displays-Visual displays that move with the participant's head-Visual displays that move with the participant's hand or other parts of his or her body - other sensory displays-Haptics- Smell (Olfaction)- Other Senses- Stereo Displays- Display - Characteristics of Displays-Techniques. Computer Graphics – Dimensionality - Depth Cues - Registration and Latency.

UNIT 3:AUGMENTED REALITY DIMENSION AND INTERACTION **9**

Introduction to3D objects in ARAF-advanced 3D modelling technique -Vuforia Overview: Interface, Navigation, Terminology, Image Targeting, Custom Images-Recognition process

with Vuforia- Use of Vuforia descriptor in ARAF -Real World-Manipulation-Navigation-Mobile Augmented Reality.

UNIT 4:AUGMENTED REALITY WITH GEOLOCATION **9**

Create an AR Quiz using the authoring tool - Geolocation in ARAF- A basic example: Image PROTO-Enriching a prototype: add user interaction- Map PROTO- Map Marker PROTO-Map Overlay PROTO-Map Player PROTO- An example of a functional map in ARAF.

UNIT 5:APPLICATION **9**

Pokemon GO and its effect on AR & Augmented Reality Gaming - Survey of Current AR Games - ARKit GPS Template- Augmented Reality Wearable Survey of Augmented Reality Wearables, AR for Medical and Psychotherapy Bio-sensing and AR with the server - The future of augmented reality.

TOTAL: 45 PERIODS

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

CO1: Understand the concept of augmented reality

CO2: Effectively design and benefits of AR.

CO3: Understand the dimension and interaction of AR

CO4: Incorporate of Geo-location with AR

CO5: Apply AR for real-time applications

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	3	3	2	2						2	2
CO2	2	3	3	3	3	3	3				2	2	2	3
CO3	2	2	2	2	2	2	2		2	2	2	3		
CO4	2	2	3	3	2	3	3		2	3			2	2
CO5	2	3	3	2	2	3	3	3	3	3	3	2	2	3

TEXT BOOKS:

1Pangilinan, Erin, Lukas, Steve, Mohan, Vasanth. Creating Augmented and Virtual Realities: Theory and Practice for Next-Generation Spatial Computing. Taiwan: O'Reilly Media, 2019.

2. Mealy, Paul. Virtual & Augmented Reality For Dummies. Germany: Wiley, 2018.

REFERENCE BOOKS:

1. Designing, Deploying, and Evaluating Virtual and Augmented Reality in Education. United States: IGI Global, 2020.

2. Linowes, Jonathan, Babilinski, Krystian. Augmented Reality for Developers: Build Practical Augmented Reality Applications with Unity, ARCore, ARKit, and Vuforia. United Kingdom: Packt Publishing, 2017.
WEB RESOURCES:
1 Industry 4.0: Augmented Reality and Virtual Reality https://www.youtube.com/watch?v=zLMgdYI82IE
2.Augmented Reality - Fundamentals and Development https://www.youtube.com/watch?v=MGuSTAqlZ9Q

EE606709-MEMS TECHNOLOGY					
Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**
COURSE OBJECTIVES:					
• To introduce the diverse technological and functional approaches of MEMS and applications. • To understand the microstructures and fabrication methods. • To provide an insight of micro and nano sensors, actuators. • To emphasis the need for MEMS technology. • To update the ongoing trends and real time applications of MEMS technology.					
UNIT I INTRODUCTION TO MEMS					**9**
Overview of Micro electro mechanical systems and Nano Electro mechanical systems, devices and technologies, Laws of scaling- Materials for MEMS and NEMS - Applications of MEMS and NEMS.					
UNIT II MICRO-MACHINING AND MICROFABRICATION TECHNIQUES					**9**
Photolithography- Micro manufacturing, Bulk micro machining, surface micro machining, LIGA.					
UNIT III MICRO SENSORS AND MICRO ACTUATORS					**9**
Micromachining: Capacitive Sensors- Piezoresistive Sensors- Piezoelectric actuators.					
UNIT IV MEMS TECHNOLOGY					**9**

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

UNIT V MEMS APPLICATION	**9**

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

TOTAL: 45 PERIODS

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

CO1: Explain the material properties and the significance of MEMS and NEMS for industrial automation.

CO2: Demonstrate knowledge delivery on micromachining and micro fabrication

CO3: Apply the fabrication mechanism for MEMS sensor and actuators.

CO4: Apply the concepts of MEMS to models, simulate and process the sensors and actuators.

CO5: Apply the concepts of MEMS to models, simulate and process the sensors and actuators.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	1	3	-	-	1	-	3	-	1	3	-
CO2	3	3	2	1	3	-	-	1	-	3	-	1	3	-
CO3	3	2	2	1	3	-	-	1	-	3	-	1	3	-
CO4	3	2	2	1	3	-	-	1	-	3	-	1	3	-
CO5	3	2	2	1	3	-	-	1	-	3	-	1	3	-

TEXT BOOKS:

1. Chang Liu, “Foundations of MEMS”, Pearson International Edition, 2011, 2nd Edition.

2. Tai-.Ran Hsu, “MEMS and Microsystems: design, manufacture, and Nanoscale”- 2nd Edition, John Wiley & Sons, Inc., Hoboken, New Jersey, 2008.

3. Julian W Gardner and Vijay K Varadan, “Microsensors, MEMS and Smart Devices”, John Wiley and Sons Ltd, 2001, 1st Edition.

REFERENCE BOOKS:

1. Marc F madou“Fundamentals of micro fabrication” CRC Press 2002 2nd Edition Marc Madou.

2. M.H.Bao "Micromechanical transducers: Pressure sensors, accelerometers and gyroscopes", Elsevier, Newyork, 16 Oct 2000, 1st Edition.

WEB RESOURCES:

1. **Lectures** on **MEMS and** MICROSYSTEMS **DESIGN AND MANUFACTURE**
https://www.academia.edu/Lectures_on_MEMS_and_MICROSYSTEMS_DESIGN_AND_M ANUFACTURE
2. **MEMS fabrication**.
https://www.iitk.ac.in/me/mems-fabrication
3. **MEMS fabrication** area develop micro scale technologies.
http://mems.iiti.ac.in/

EE606710-NANO SENSOR AND ITS APPLICATIONS

Course Category: Program Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To understand the **Concept of** Sensor Characteristics And Physical Effects
- To understand the Nano Based Inorganic Sensors
- To **Developing** Biological Treatment of Solid and Hazardous Waste

UNIT I Sensor Characteristics And Physical Effects **9**

Active and Passive sensors – Static characteristic - Accuracy, offset and linearity – Dynamic characteristics - First and second order sensors – Physical effects involved in signal transduction- Photoelectric effect – Photo dielectric effect – Photo luminescence effect – Electroluminescence effect – Hal effect – Thermoelectric effect – Peizoresistive effect – Piezoelectric effect – Pyro electric effect –Magneto mechanical effect (magnetostriction) – Magneto resistive effect.

UNIT II Nano Based Inorganic Sensors **9**

Density of states (DOS) – DOS of 3D, 2D, 1D and 0D materials – one dimensional gas sensors:- gas sensing with nanostructured thin films – absorption on surfaces – metal oxide modifications by additives – surface modifications – Nano optical sensors – Nano mechanical sensors – Plasmon resonance sensors with Nano particles – AMR, Giant and

colossal magneto resistors – magnetic tunneling junctions.

UNIT III Organic / Biosensors:	**9**

Structure of Protein – role of protein in nanotechnology – using protein in Nano devices – antibodies in sensing – antibody in Nano particle conjugates – enzymes in sensing – enzyme nanoparticle hybrid sensors – Motor proteins in sensing – trans membrane sensors – Nano sensors based on Nucleotides and DNA – Structure of DNA – DNA decoders and microarrays – DNA protein conjugate based sensors – Bioelectronics sensors – DNA sequencing with Nano pores – sensors based on molecules with dendritic architectures – bio magnetic sensors.

UNIT IV Nano Sensors	**9**

Temperature Sensors, Smoke Sensors, Sensors for aerospace and defense: Accelerometer, Pressure Sensor, Night Vision System, Nano tweezers, Nano-cutting tools, Integration of sensor with actuators and electronic circuitry Biosensors

UNIT V Applications	**9**

Cantilever array sensors - Cantilever sensors for diagnosis of diabetes mellitus - Cantilever sensors for cancer diagnosis - Nanotube based sensors - Nanotube based sensors for DNA detection - Nanotube based sensors for scenography - Nanowire based sensors - Nanowire based electrical detection of single viruses - Nanowire based electrical detection of biomolecules.

TOTAL: 45 PERIODS

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

CO1: Describe about Sensor Characteristics And Physical Effects

CO2: Explain knowledge about Nano Based Inorganic Sensors

CO3: Demonstrate the Organic and Biosensors

CO4: Analyze the different types of Nano Sensors .

CO5: Study the concepts of Applications of Nano sensor.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	2	1	1					3	1	1	3	2
CO2	2	3	2	1	1					3	1	1	3	2
CO3	2	2	2	1	1							1		
CO4	2	2	2	1	1	2	2	1	2			1	3	2

CO5	2	2	2	1	1	2	2	1	2	3	1	1		

TEXT BOOKS:

1. Nanofabrication for Smart Nano sensor Applications. Netherlands: Elsevier Science, 2020.

2. Nano sensors for Environmental Applications. Germany: Springer International Publishing, 2020.

REFERENCE BOOKS:

1. Kourosh Kalantar – Zadeh, Benjamin Fry, "Nanotechnology- Enabled Sensors", Springer, 2019.

2. H.Rosemary Taylor, "Data acquisition for sensor systems", Chapman & Hall, 1997.

WEB RESOURCES:

1. **Nanotechnology** and **Nano sensors**. https://www.coursera.org/learn/nanotechnology1

2. Nanostructures and Nanomaterials: Characterization and Properties https://nptel.ac.in/courses/118104008

INSTITUTE ELECTIVE COURSES OFFERED BY DEPARTMENT OF EEE

EE607108-CONVENTIONAL AND NON-CONVENTIONAL SOURCES OF ENERGY

Course Category: Institute Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To impart knowledge on the various energy resources and their applications.
- To impart knowledge on the construction and operation of various conventional power generation.
- To impart knowledge on the construction and operation of various non-conventional power generation.

UNIT I THERMAL AND HYDRO POWER PLANTS	9

Basic thermodynamic cycles- Various components of steam power plant-layout - pulverized coal burners- Fluidized bed combustion - coal handling systems-ash handling systems - Forced draft and induced draft fans- Boilers - feed pumps-super heater – regenerator – condenser- deaearators -cooling tower - Electro static precipitator.

Site selection for hydroelectric power plant - Layout - dams - selection of water turbines-types of hydro turbine - Classification of hydroelectric power plant- pumped storage hydro plants-Advantages

UNIT II NUCLEAR AND GAS POWER PLANTS	9

Various components of nuclear power plant - layout - Principles of nuclear energy - Types of Nuclear reactions - nuclear reactor - Types of Reactor - Nuclear waste &its disposal-Case study.

Types of gas power plants - open and closed cycle gas turbine- work output & thermal efficiency - methods to improve performance - reheating – inter coolings – regeneration - advantage and disadvantages – applications

UNIT III WIND AND OCEAN ENERGY	9

Basic principles of wind energy conversion- wind data and energy estimation-site selection considerations - Basic components of WECS- Classification of WEC systems - Types of Wind machines - Performance of wind machines - Generating systems-energy storage - Applications of wind energy

Ocean thermal energy conversion - types of OTEC power generation- open and closed cycle OTEC systems –generation of tidal energy – tidal power generation methods – barrage tidal power – Applications

UNIT IV SOLAR AND GEOTHERMAL ENERGY	9

Introduction-Solar constant-Solar radiation on the earth's surface-solar energy conversion into heat, Flat plate and concentrating collectors - Energy balance equation and collector efficiency - Solar energy storage system - Applications of solar energy: solar photo-voltaic, agricultural and industrial process heating, solar cooking, solar production of hydrogen.

Geothermal energy sources – Geothermal power plants technology – other applications of geothermal energy.

UNIT V BIO MASS AND OTHER ENERGY RESOURCES	9

Bio mass conversion technologies - classification of Bio mass plants- Constructional details

of some main digesters -Site selection- Thermal gasification of Biomass - Advantages and disadvantages of Biological conversion of solar energy.

Design and Principle operations of Fuel Cell- classification of fuel cells-Advantages and disadvantages of fuel cells - MHD power generation-Voltage and power output of MHD generator - Thermo electric power generation

TOTAL: 45 PERIODS

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

CO1: Describe the operation of thermal and hydro power plant and its application
CO2: Explain the operation of nuclear and gas power plant and its application
CO3: Explain the function of wind and ocean based power generation and its application
CO4: Discuss the importance and function of solar and geothermal based power generation
CO5: Describe the operation of Biomass and other renewable power generation and its application

CO-PO MAPPING

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

TEXT BOOKS:

1. A Course in Power Plant Engineering by Arora and Domkundwar, S Chand Publications, 8th edition, 2016.

2. G.D.Rai., “Non-Conventional Energy Sources” Khanna Publications, Fourth Edition 2010, 29th Reprint.

REFERENCE BOOKS:

1. P.K.Nag, Power Plant Engineering, McGraw Hill, 4th edition, 2010.

2. R.K.Rajput, A Text book on Power Plant Engineering, Laxmi Publications, 5th edition, 2016.

3. Samsher Gautam “Power Plant Engineering” Vikas Publications, 2016.

WEB RESOURCES:

Power Plant Engineering. https://archive.nptel.ac.in/courses/112/107/112107291/

EE607109-ELECTRIC VEHICLES

Course Category: Institute Elective	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To introduce the fundamental concepts, principles, analysis and design of hybrid, electric and fuel cell vehicles.

UNIT I INTRODUCTION	**9**

Introduction, Components, vehicle mechanics – Roadway fundamentals, vehicle kinetics, Dynamics of vehicle motion - Propulsion System Design.

UNIT II BATTERY	**9**

Basics – Types, Parameters – Capacity, Discharge rate, State of charge, state of Discharge, Depth of Discharge, Technical characteristics, Battery pack Design, Properties of Batteries, operating features of Li-ion battery.

UNIT III DC & AC ELECTRICAL MACHINES	**9**

Motor and Engine rating, Requirements, DC machines, Three phase A/c machines, Induction machines, permanent magnet machines, switched reluctance machines.

UNIT IV ELECTRIC VEHICLE DRIVE TRAIN	**9**

Transmission configuration, Components – gears, differential, clutch, brakes regenerative braking, motor sizing.

UNIT V HYBRID ELECTRIC VEHICLES	**9**

Types – series, parallel and series, parallel configuration – Design – Drive train, sizing of components.

TOTAL: 45 PERIODS

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

CO1: Understand the working of different configurations of electric vehicles.
CO2: Understand the hybrid vehicle configuration and its components, performance analysis
CO3: Understand the properties of batteries and its types
CO4: Understand the electric vehicle drive systems
CO5: Understand the hybrid electric vehicles

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	

CO1	2	3	2	1	1					3	1	1
CO2	3	3	2	2	1					3	1	2
CO3	3	2	2	3	1							3
CO4	3	2	2	1	1	2	2	1	2			2
CO5	2	2	2	1	1	2	2	1	2	3	1	1

TEXT BOOKS:

1. Larminie, James, and Lowry, John. Electric Vehicle Technology Explained. Germany, Wiley, 2012.
2. Iqbal Hussain, "Electric & Hybrid Vehicles – Design Fundamentals", Second Edition, CRC Press, 2011.
3. Muneer, Tariq, Electric Vehicles: Prospects and Challenges. Netherlands, Elsevier Science, 2017.

REFERENCE BOOKS:

1. Mehrdad Ehsani, Yimin Gao, Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals", CRC Press, 2010.
2. Hybrid Electric Vehicles. Croatia, IntechOpen, 2017.

WEB RESOURCES:

Fundamentals of Electric Vehicles. https://nptel.ac.in/courses/108106170

EE607207 - HYBRID ENERGY TECHNOLOGY

Course Category: Institute Elective	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To provide knowledge about different types of hybrid energy systems.
- To analyze the various electrical Generators used for the Wind Energy Conversion Systems.
- To design the power converters used in Solar PV Systems.

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

Hybrid Energy Systems – Need for Hybrid Energy Systems – Solar-Wind-Fuel Cell-Diesel, Wind, Biomass-Diesel, Micro Hydel - PV, Ocean and geyser energy - Classification of Hybrid Energy systems – Importance of Hybrid Energy systems – Advantages and Disadvantages - Environmental aspects of renewable energy - Impacts of renewable energy

generation on the environment - Present Indian and international energy scenario of conventional and RE sources - Ocean energy, Hydel Energy - Wind Energy, Biomass energy, Hydrogen energy - Solar Photovoltaic (PV) and Fuel cells: Operating principles and characteristics	
UNIT II ELECTRICAL MACHINES FOR WIND ENERGY CONVERSION SYSTEMS (WECS)	**9**
Review of reference theory fundamentals –Construction, Principle of operation and analysis: Squirrel Cage Induction Generator (SCIG), Doubly Fed Induction Generator (DFIG) - Permanent Magnet Synchronous Generator (PMSG).	
UNIT III POWER CONVERTERS AND ANALYSIS OF SOLAR PV SYSTEMS	**9**
Power Converters for SPV Systems - Line commutated converters (inversion-mode) - Boost and buckboost converters- selection of inverter, battery sizing, array sizing - Analysis of SPV Systems - Block diagram of the solar PV systems - Types of Solar PV systems: Stand-alone PV systems	
UNIT IV ANALYSIS OF POWER CONVERTERS FOR HYBRID ENERGY SYSTEMS	**9**
Introduction to Power Converters – Stand-alone Converters -AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters - Bi-Directional Converters - Grid-Interactive Inverters - Matrix converter – Merits and Limitations.	
UNIT V CASE STUDIES FOR HYBRID RENEWABLE ENERGY SYSTEMS	**9**
Hybrid Systems- Range and type of Hybrid systems – Performance Analysis – Cost Analysis - Case studies of Diesel-PV, Wind-PV-Fuel-cell, Micro-hydel-PV, Biomass-Diesel-Fuel-cell systems.	
TOTAL: 45 PERIODS	
COURSE OUTCOMES: At the end of the course, the student will be able to	
CO1: Analyze the impacts of hybrid energy technologies on the environment and demonstrate them to harness electrical power	
CO2: Select a suitable Electrical machine for Wind Energy Conversion Systems and simulate wind energy conversion system	

CO3: Design the power converters such as AC-DC, DC-DC, and AC-AC converters for SPV systems.

CO4: Analyze the power converters such as AC-DC, DC-DC, and AC-AC converters for Hybrid energy systems.

CO5: Interpret the hybrid renewable energy systems.

CO-PO MAPPING

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

TEXT BOOKS:

1. Md. Rabiul Islam, Md. Rakibuzzaman Shah, Mohd Hasan Ali, "Emerging Power Converters for Renewable Energy and Electric Vehicles", CRC Press, First Edison, 2021

2. Hybrid Renewable Energy Systems and Micro grids. Netherlands: Elsevier Science, 2020.

3. Hybrid Energy System Models. Netherlands: Elsevier Science, 2020.

REFERENCE BOOKS:

1. Hybrid Renewable Energy Systems, United States: Wiley, 2021.

2. Kircicek, Y., Aktas, A. Solar Hybrid Systems: Design and Application. United States: Elsevier Science, 2021

3 Luo, Y., Shi, Y., Cai, N. Hybrid Systems and Multi-energy Networks for the Future Energy Internet. Netherlands: Elsevier Science, 2020.

WEB RESOURCES

1. Hybrid Energy System. https://www.sciencedirect.com/topics/engineering/hybrid-energy-system

2. Wind-Energy-Conversion-System

https://www.sciencedirect.com/topics/engineering/wind-energy-conversion-system

EE607208 - SMART GRID TECHNOLOGY					
Course Category: Institute Elective	**Course**	**L**	**T**	**P**	**C**

	Type: Theory	3	0	0	3

COURSE OBJECTIVES:

- To understand how electricity is priced in a transmission network.
- To evaluate the trade-off between economics and reliability of an electric power system.
- To understand the impacts of renewable resources to the grid and the various issues associated with integrating such resources to the grid.

UNIT I INTRODUCTION	**9**

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

UNIT II SMART GRID TECHNOLOGIES	**9**

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

UNIT III RENEWABLE INTEGRATION AND INVESTMENT VALUATION	**9**

Renewable integration: dealing with short-term variation - Renewable integration: impacts on long-term reliability - Demand-side participation and dynamic pricing - Impacts of Smart Grid on reliability - Impacts of Smart Grid on air pollutant emissions reduction

UNIT IV SECURITY AND PRIVACY	**9**

Cyber Security Challenges in Smart Grid - Load Altering Attacks - False Data Injection Attacks - Defense Mechanisms - Privacy Challenges - Economics and Market Operations - Energy and Reserve Markets - Market Power - Generation Firms - Locational Marginal Prices - Financial Transmission Rights

UNIT V MICROGRIDS AND DISTRIBUTED ENERGY	**9**

RESOURCES

Concept of microgrid, need & application of microgrid, formation of microgrid, Issues of interconnection, protection & control of microgrid, Plastic & Organic solar cells, thin flim solar cells, Variable speed wind generators, fuel cells, microturbines, Captive power plants, Integration of renewable energy sources.

TOTAL: 45 PERIODS

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

CO1: Explain various aspects of the smart grid, including, Technologies, Components, Architectures and Applications.

CO2: Explain communication infrastructure of smart grid.

CO3: Explain various integration aspects of conventional and non-conventional energy sources.

CO4: Explain distributed generation coordination including monitoring of smart grid using modern communication infrastructure.

CO5: Analyze microgrid as a hybrid power system with advantages and challenges in future.

CO-PO MAPPING

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

TEXT BOOKS:

1. Ali Keyhani, Mohammad N. Marwali, Min Dai, Integration of Green and Renewable Energy in Electric Power Systems, Wiley, 2017.

2. Clark W. Gellings, The Smart Grid: Enabling Energy Efficiency and Demand Response, CRC Press, 2014.

3. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, Smart Grid: Technology and Applications, Wiley, 2011.

REFERENCE BOOKS:

1. Andres Carvallo, John Cooper, The Advanced Smart Grid: Edge Power Driving Sustainability, Artech House Publishers July 2011.

2. Wilson, Robert G., and Northcote-Green, James. Control and Automation of Electrical Power Distribution Systems. United Kingdom, CRC Press, 2017.

3. Momoh, James A. Electric Power Distribution, Automation, Protection, and Control. United States, CRC Press, 2017.

WEB RESOURCES

Smart Grid: Basics to Advanced Technologies – Course.

https://onlinecourses.nptel.ac.in/noc23_ee60/preview

EE607209- INSTRUMENTATION SYSTEMS					
Course Category: Institute Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- Enable the student to interpret the various types of non-electrical parameter measurement.

UNIT 1: MEASUREMENT OF FORCE, TORQUE AND SPEED **9**

Force measurement – Hydraulic loadcell – Pneumatic load cell – Strain gauge load cell – Magneto elastic load cell – Piezoelectric load cell - Torque measurement – Strain gauge torsion meter - Relative regular twist method – Optical torsion meter – Electrical torsion meter – Speed measurement – Revolution counter – Capacitive tachometer - Drag cup type tachometer – D.C and A.C tacho generators – Magnetic pickup – Photoelectric pickup – Stroboscope.

UNIT 2: MEASUREMENT OF DISPLACEMENT, ACCELERATION, VIBRATION AND DENSITY **9**

Measurement of linear and angular displacement - potentiometer, LVDT, piezo-electric, strain gauge accelerometers - measurement of vibration - seismic instrument as an accelerometer and vibrometer -density and specific gravity - Baume and API(American Petroleum Institute) scales - pressure head type densitometer - float type densitometer - ultrasonic densitometer - bridge type gas densitometer.

UNIT 3: MEASUREMENT OF PRESSURE AND TEMPERATURE **9**

Pressure measurement: Manometer-Elastic type pressure transducers - McLeod gauge - Thermal conductivity gauge - Ionization gauge - Dead weight tester - Temperature

measurement: RTD - Two lead, three lead, four lead wire RTDs - Thermistors – Thermocouple - thermoelectric laws, types and cold junction compensation - Bimetallic thermometer – Pyrometer - Total radiation pyrometer, Optical pyrometer.

UNIT 4: MEASUREMENT OF LEVEL AND FLOW **9**

Level measurement: Float, Displacer type, Bubbler system, Resistance, Capacitance type - Flow measurement: Variable Head flowmeter - Orifice, Venturi tube, Flow nozzle, Dall tube, Pitot tube – Variable area flowmeter – Rotameter – Velocity measurement type flow meter – Hotwire anemometer – Positive displacement type flowmeter – Nutating disc type flowmeter - Turbine flowmeter - Electro Magnetic flow meter - Mass flow meter - Thermal, Coriolis type - Vortex shedding - Target flowmeter.

UNIT 5: MEASUREMENT OF VISCOSITY AND HUMIDITY **9**

Viscosity - Units - Terminologies – Capillary tube viscometer – Ostwald viscometer – Efflux viscometer: - Say bolt viscometer – Redwood viscometer – Engler viscometer - Rotameter type viscometer – Humidity terms – Sling psychrometer – Absorption hygrometer: - Mechanical humidity sensing absorption hygrometer – Electrical humidity sensing absorption hygrometer – Dew point meter.

TOTAL: 45 PERIODS

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

CO1: Analyze the functions of force, torque and speed measurement.

CO2: Understand the measurement of acceleration, vibration and density.

CO3: Apply the pressure, temperature measurement techniques.

CO4: Understand the level and flow measurement techniques.

CO5: Apply the viscosity and humidity measurement techniques.

CO-PO MAPPING

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

TEXT BOOKS:

1. Eckman D.P., “Industrial Instrumentation”, Wiley Eastern Limited, 1990.

2. Singh,S.K., “Industrial Instrumentation and Control”, Tata Mc-Graw-Hill Education Pvt. Ltd., New Delhi, 2009.

3. Jain, R.K., Mechanical and Industrial Measurements, Khanna Publishers, Delhi, 1999.

4. Patranabis, D., “Principles of Industrial Instrumentation”, 3rd Edition, Tata McGraw-Hill
Publishing Company Ltd., New Delhi, 2010.

REFERENCE BOOKS:

1. Doebelin, E.O. and Manik, D.N., “Measurement systems Application and Design”, 6th McGraw-Hill Education Pvt. Ltd, 2011.

2. Liptak, B.G., “Instrumentation Engineers Handbook (Measurement)”, CRC Press, 2005.

WEB RESOURCES:

1. INDUSTRIAL INSTRUMENTATION
https://archive.nptel.ac.in/courses/108/105/108105064/

2. INDUSTRIAL INSTRUMENTATION
https://kanchiuniv.ac.in/coursematerials/industrial_instrumentation_k_saraswathi.pdf

EE607309 - PROCESS CONTROL AND AUTOMATION

Course Category: Institute Elective	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the dynamic modelling of a physical processes.
- To familiarize about different process instruments.

UNIT 1: PROCESS MODELLING AND DYNAMICS — **9**

Introduction and Need for Process Control – Mathematical Model of First order Level, Pressure and Temperature Processes —higher order process – Interacting and Non Interacting Systems – Degrees of freedom –Continuous and Batch Process – Self Regulation process– Servo and Regulatory Operation.

UNIT 2: CONTROL ACTIONS AND CONTROLLERS — **9**

Basic Control actions – Characteristics of On Off, Proportional, Integral and Derivative

Control Modes – P+I, P+D, P+I+D Control Modes-PID Implementation Issues: Bumpless, Auto/manual mode transfer, Anti-reset windup techniques – Direct/reverse action – one quarter decay ratio – Tuning – Process reaction curve method, Continuous cycling method and Damped oscillation method.

UNIT 3: MULTILOOP CONTROL **9**

Feed-forward control – Feed-forward plus Feedback control Scheme – Ratio control – Cascade control –Inferential control –Split-range control– Selective control system-Override control – Auctioneering control.

UNIT 4: FINAL CONTROL ELEMENTS **9**

Signal conversion – I/P, P/I Converters – Actuators: Pneumatic and electric actuators – Control Valve Terminology – Characteristic of Control Valves: Inherent and Installed characteristics – Valve Positioner- Control Valve Sizing – Cavitation and flashing.

UNIT 5: PLC AND SCADA **9**

PLC: Components of PLC – Ladder logic programming-Timers: On Delay timer, OFF Delay timer and Retentive timer – Counters: Up Counter and Down Counter. Data manipulation instructions – Math instructions SCADA: Basic architecture of SCADA – Integration of SCADA system with PLC – SCADA hardware and software – Remote Terminal Unit – Master Station and HMI Computer(s) – Communication Infrastructure.

TOTAL: 45 PERIODS

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

CO1: Develop mathematical models for first order and higher order processes.

CO2: Apply suitable control mode for different applications.

CO3: Analyze the various control schemes and obtain optimum controller settings using tuning Methods.

CO4: Understand the construction, working and selection of final control elements for a closed loop control system.

CO5: Ability to apply complex control schemes for various process applications and draw P&ID diagrams for various processes.

CO-PO MAPPING

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

CO3	3	3	3	2	2	-	-	-	-	-	2	2
CO4	3	3	3	3	3	-	-	-	-	-	2	3
CO5	3	3	3	3	3	-	-	-	-	-	2	1

TEXT BOOKS:

1. Eckman D P, "Automatic Process Control", Wiley Eastern Ltd., New Delhi, 1993.

2. George Stephanopoulos, Chemical Process Control, PHI learning Pvt. Ltd., New Delhi, 2012.

3. C. D. Johnson, "Process Control Instrumentation Technology", 8th Edition, Prentice 2015.

4. F.D. Petruzella, Programmable Logic Controllers, Tata Mc-Graw Hill, Third edition, 2010.

REFERENCE BOOKS:

1. D.R. Coughanowr, Process Systems Analysis and control, McGraw Hill, Singapore, 3rd Edition, 2009.

2. B.Wayne Bequette, Process Control Modelling, Design and Simulation, PHI learning Pvt. Ltd., New Delhi, 2010.

3. Peter Harriott, Process Control, Tata McGraw Hill publishing Co. Ltd., New Delhi, 30th reprint 2010.

4. Bela.G.Liptak., Process Control and Optimization‖., Instrument Engineers Handbook, volume 2, CRC press and ISA, 2005.

WEB RESOURCES:

1. Process Control - Design, Analysis and Assessment
https://www.digimat.in/nptel/courses/video/103106148/L01.html

2. Chemical process control.
https://archive.nptel.ac.in/courses/103/101/103101142/

3. Introduction to Industrial Automation and Control.
https://nptel.ac.in/courses/108105063

EE607308- INDUSTRIAL AUTOMATION

Course Category: Institute Elective	Course Type: Theory	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:		
To understand the fundamentals of Programmable Logic Controller (PLC), Supervisory Control and Data Acquisition (SCADA) and Distributed Control System (DCS).		
UNIT 1: PROGRAMMABLE LOGIC CONTROLLER		**9**
Evolution of PLC's – Components of PLC – Advantages over relay logic – Architecture of PLC–Programming devices – Discrete and Analog I/O modules – Programming languages – Ladder diagram – Programming timers and counters – design of PLC – integration of PLC with process.		
UNIT 2: PLC SCADA AND ITS APPLICATIONS		**9**
Instructions in PLC – Program control instructions, math instructions, sequencer instructions – Use of PC as PLC – Application of PLC – Case study of bottle filling system – material handling system – automatic stamping system – Introduction to SCADA – components of SCADA – features of SCADA		
UNIT 3: DISTRIBUTED CONTROL SYSTEM		**9**
Evolution – Building blocks – Field controlled units – Operator stations – Data highways – Redundancy concepts – Communication in DCS – DCS system integration with PLC and computers.		
UNIT 4: INTERFACES IN DCS		**9**
Operator interfaces – Low and High level operator interfaces – operator displays – Engineering interfaces – Low and High level engineering interface.		
UNIT 5: INDUSTRIAL DATA COMMUNICATION		**9**
Evolution of signal standards – HART Communication protocol – TCP/IP protocol – Communication modes - HART networks – Control system interface – HART Model – Field bus introduction – General Field bus architecture – Basic Requirements of field bus standard – Field bus topology – Interoperability – Introduction to safety in PLC – IoT – Cyber Security.		
TOTAL: 45 PERIODS		
COURSE OUTCOMES: At the end of the course, the student will have the		
CO1: Ability to develop the PLC program for various applications.		
CO2: Ability to explore the function of supervisory control and data acquisition.		

CO3: Ability to interpret the functions of Distributed Control Systems.

CO4: Ability to analyse the data with interfaces in distributed control systems.

CO5: Ability to understand industrial data communication.

CO-PO MAPPING

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

TEXT BOOKS:

1. Petruzella, Industrial Electronics‟, McGraw Hill, third edition, 2010.

2. Michael P. Lukas, “Distributed Control System”, Van Nostrand Reinhold Co., Canada, first edition 1986.

3. John. W. Webb Ronald A Reis – Programmable Logic Controllers – Principles and Applications, Fourth edition, Prentice Hall Inc., New Jersey, 1998.

4. Romily Bowden, HART application guide and OSI communication Foundation; 1999.

REFERENCE BOOKS:

1. Krishna Kant, “Computer Based Industrial Control” Prentice Hall India, 1997.

2. McMillan, G.K., “Process/Industrial Instrument and Controls Handbook”, 5thEdition, McGraw- Hill handbook, New York, 1999.

3. John Park, Steve Mackay, Edwin Wright, Practical data communications for instrumentation and control, Newnes/Elsevier, 2013.

WEB RESOURCES:

1. PLC. https://instrumentationtools.com/what-is-a-plc/

2. NPTEL Course, Industrial Automation And Control by Prof. Siddhartha Mukhopadhyay, IIT Kharagpur. https://nptel.ac.in/courses/108105063

EE607310-AUTOMOTIVE EMBEDDED SYSTEM AND APPLICATIONS					
Course Category: Institute Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**
COURSE OBJECTIVES:					

- To learn the fundamentals and building of Electronic Engine Control systems
- To study the functional components and circuits for vehicles
- To study the programmable controllers for vehicles
- To learn logics of automation & commercial techniques for vehicle communication

UNIT 1: BASICS OF ELECTRONIC ENGINE CONTROL SYSTEMS	**9**

Motivation, concept for electronic engine controls and management- Standards; introduction to fuel economy- automobile sensors-volumetric, thermal, air-fuel ratio, solenoid, hall effect-exhaust gas oxygen sensors, Oxidizing catalytic efficiency, emission limits and vehicle performance

UNIT 2:FUEL CELL FOR AUTOMOTIVE POWER	**9**

Fuel cell-Introduction-Proton exchange membrane FC (PEM), Solid oxide fuel cell (SOFC)-properties of fuel cells for vehicles-power system of an automobile with fuel cell based drive, and their characteristics.

UNIT 3:VEHICLE MANAGEMENT SYSTEMS	**9**

Electronic Engine Control-engine mapping, air/fuel ratio spark timing control strategy, fuel control, electronic ignition-Vehicle cruise control- speed controlant locking braking system-electronic suspension - electronic steering , wiper control ; Vehicle system schematic for interfacing with EMS,ECU. Energy Management system for electric vehicles- for sensors, accelerators, brake- Battery management, Electric Vehicles-Electrical loads, power management system-electrically assisted power steering system.

UNIT 4:AUTOMOTIVE TELEMATICS	**9**

Role of Bluetooth, CAN, LIN and flex ray communication protocols in automotive applications; Multiplexed vehicle system architecture for signal and data / parameter exchange between EMS,ECUs with other vehicle system components and other control systems

UNIT 5:ELECTRONIC DIAGNOSTICS FOR VEHICLES	**9**

System diagnostic standards and regulation requirements –On board diagnosis of vehicles electronic units & electric units-Speedometer, oil and temperature gauges, and audio system

TOTAL: 45 PERIODS

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

CO1: Design and develop automotive embedded systems.

CO2: Analyse various embedded products used in the automotive industry.

CO3: Evaluate the opportunities involving technology, a product or a service required for developing a startup idea used for automotive applications.

CO4: Understand the diagnostics techniques for electric vehicles.

CO5: Understand the diagnostics standards for electric vehicles.

CO-PO MAPPING

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

TEXT BOOKS:

1. Denton, Tom. Automobile Electrical and Electronic Systems. United Kingdom: CRC Press, 2017.

2. Zaman, Najamuz. Automotive Electronics Design Fundamentals. Germany: Springer International Publishing, 2015.

3. Abudbaker, S, Mahroogi, Faisal O., Alammari, Youssef, Sakthivel, R., Kaisan, M. U.., Narayan, S. Introduction to Automotive Engineering. United States: Wiley, 2019.

REFERENCE BOOKS:

1. Intelligent Vehicles: Enabling Technologies and Future Developments. Netherlands: Elsevier Science, 2017.

2. VanGelder, Kirk T. Automotive Electricity and Electronics. United States: Jones & Bartlett Learning, 2017.

3. Handbook of Automotive Power Electronics and Motor Drives. United States: Taylor & Francis, 2017.

WEB RESOURCES:

1 - Introduction to Automotive Embedded Systems & Autosar
https://www.youtube.com/watch?v=pHCBOLidXOY

2.Embedded Systems Basics
https://nptel.ac.in/courses/117106112

EE607407-HYBRID AND ELECTRIC VEHICLE ENGINEERING					
Course Category: Institute Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**

			3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To know the fundamental of electric and hybrid vehicle.
- To understand working principle of electric propulsion system.
- To know the energy storage techniques for electric and hybrid vehicles.
- To know the concept of regenerative braking system.
- To understand concept of fuel cell vehicle.

UNIT I ELECTRIC VEHICLES	**9**

Introduction - Configurations of Electric Vehicles, Performance of electric vehicles – Traction motor characteristics, tractive effort, transmission requirements, vehicle performance, Tractive Effort in Normal Driving, energy consumption, advantage and limitations – Autonomous Vehicles.

UNIT II HYBRID ELECTRIC VEHICLES	**9**

Introduction - Need for HEV - Architectures of Hybrid Electric Drive Trains- Series Hybrid Electric Drive Trains- Parallel Hybrid Electric Drive Trains - Torque coupling, speed coupling and both – Electric and hybrid vehicles comparison – Case studies.

UNIT III ELECTRIC PROPULSION SYSTEMS	**9**

DC motor drives- Principle of Operation and Performance- induction motor drives- Basic Operation Principles & Steady-State Performance - Permanent magnetic BLDC motor drives - Basic Principles & Construction and Classification - switched reluctance motor drives - Basic Magnetic Structure, Torque Production, SRM Drive Converter, Modes of Operation.

UNIT IV ENERGY STORAGES AND REGENERATIVE BRAKING	**9**

Basics of Electrochemical batteries - Ultra-capacitors- Ultra high-Speed Flywheels - Regenerative braking - Braking energy consumed in urban driving – braking energy vs vehicle speed, braking power, vehicle speed, vehicle deceleration rate – braking energy on front and rear axles – brake system of EV, HEV and FCV.

UNIT V FUEL CELLS	**9**

Principles of Fuel Cells-Fuel Cell Technologies- Proton Exchange Membrane, Alkaline, Phosphoric Acid, Molten Carbonate, Solid Oxide, Direct Methanol fuel cells - Fuel Supply- Hydrogen Storage, Hydrogen Production- Non hydrogen Fuel Cells.

TOTAL: 45 PERIODS

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

CO1: Understand the configurations and performance of electric vehicle

CO2: Explain hybrid electric vehicle

CO3: Analyze the different types of electric propulsion systems

CO4: Distinguish different concept of energy storage and regenerative braking.

CO5: Explain the fuel cell technologies.

CO-PO MAPPING

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

TEXT BOOKS:

1. Mehrdad Ehsani, Yimin Gao, Stefano Longo Kambiz M. Ebrahimi, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles”, CRS Press, 2018.

2. Husain, Iqbal. Electric and Hybrid Vehicles: Design Fundamentals. United States, CRC Press, 2021.

REFERENCE BOOKS:

1. Iqbal Husain “Electric and Hybrid Vehicles: Design Fundamentals” CRC Press, 2011.

2. Seref Soylu “Electric Vehicles - The Benefits and Barriers” InTech Publishers, Croatia, 2011.

3. Aulice Scibioh M. and Viswanathan B “Fuel Cells – Principles and Applications” University Press, India, 2008.

WEB RESOURCES:

Hybrid Electric vehicle: https://archive.nptel.ac.in/courses/108/103/108103009/

EE607408-FUZZY LOGIC CONTROLLERS

Course Category: Institute Elective	**Course Type: Theory**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To explain the basics of fuzzy Sets.
- To describe fuzzy Numbers and operations on fuzzy numbers.

- To apply defuzzification and fuzzification in sets.
- To define various relations in fuzzy setts
- To solve problems using Fuzzy Decision Making

UNIT I	INTRODUCTION ABOUT FUZZY SET THEORY	9

Introduction- Uncertainty-Imprecision and Vagueness-Fuzzy systems- Brief history of Fuzzy logic- Foundation of Fuzzy Theory- Fuzzy Sets and Systems- Representations of fuzzy sets - Extension principle for fuzzy sets – Operations of fuzzy sets – Types of operations – Fuzzy complements.

UNIT II	FUZZY NUMBERS AND OPERATIONS	9

Fuzzy Systems in Commercial Products- Research Fields in Fuzzy Theory,-Classical sets and Fuzzy sets- Classical Relations, Fuzzy relations, Membership Functions, Fuzzy to crisp conversions-Fuzzy arithmetic – Fuzzy numbers - Linguistic variables – Arithmetic operations on intervals – Arithmetic operations on fuzzy numbers – Fuzzy equations.

UNIT III	FUZZIFICATION AND DEFUZZIFICATION	9

Fuzzy arithmetic- Numbers-Vectors and the extension principle- Classical logic and Fuzzy logic-Mathematical background of Fuzzy Systems- Classical (Crisp) vs- Fuzzy sets-Representation of Fuzzy sets-Types of Membership Functions- Features of the membership function – Various forms – Fuzzification – Defuzzification to crisp sets – α-cut for fuzzy relations – Defuzzification to scalars

UNIT IV	FUZZY RELATIONS	9

Basic Concepts (support, singleton, height, a cut projections)- Fuzzy set operations- Sand T Norms, Properties of Fuzzy sets, Sets as Points in Hypercube-Cartesian Product-Crisp and Fuzzy Relations-Examples-Linguistic variables and hedges-Membership function design. Basic Principles of Inference in Fuzzy Logic Fuzzy IFTHEN Rules, Canonical Form- Fuzzy Systems-Fuzzy relations – Crisp versus fuzzy relations - Binary fuzzy relations – Binary relations on a single set - Fuzzy equivalence relations – Fuzzy compatibility relations.

UNIT V	FUZZY DECISION MAKING	9

Approximate Reasoning- Forms of Fuzzy Implication- Fuzzy Inference Engines- Graphical Techniques of Inference-Fuzzifications/Defuzzification-Fuzzy System Design and its Elements-Design options-Fuzzy Events- Fuzzy Measures-Possibility Distributions as

Fuzzy Sets, Possibility vs- Probability-Fuzzy Systems as Universal Approximations-Additive Fuzzy Systems (standard additive model).Fuzzy decision making – Individual decision making – Militiaperson decision making – Multicriteria decision making – Fuzzy ranking methods – Fuzzy linear programming.

TOTAL: 45 PERIODS

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

CO1: Understand the basics of Fuzzy system.

CO2: Compute Fuzzy numbers and operations.

CO3: Analyze the performance of Fuzzification and Defuzzification.

CO4: Analyze the performance of Fuzzy relation.

CO5: Describe the performance analysis Fuzzy decision making.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	1	2	2	-	1	2	1	3	3	1
CO2	3	3	2	2	1	2	2	-	1	2	1	3	3	1
CO3	3	2	2	2	1	2	2	-	1	2	1	3	3	1
CO4	3	2	2	2	1	2	2	-	1	2	1	3	3	1
CO5	3	2	2	2	1	2	2	-	1	2	1	3	3	1

TEXT BOOKS:

1. Fuzzy Systems: Theory and Applications. (2022). United Kingdom: IntechOpen.

2. Modern Fuzzy Control Systems and Its Applications. (2017). Croatia: IntechOpen.

3. Fuzzy Sets, Fuzzy Logic and Their Applications, MDPI AG, 2020.

REFERENCE BOOKS:

1. Ganesh M., “Introduction to Fuzzy sets and Fuzzy logic”, Prentice Hall of India, 2006.

2. Timothy J. Ross, “Fuzzy Logic with Engineering Applications”, 3rd Edition, Wiley Student Edition, 2010.

3. Zimmermann H.J., “Fuzzy Set Theory and its Applications”, Springer, 2013

WEB RESOURCES:

1. Fuzzy Sets, Logic and Systems & Applications
https://onlinecourses.nptel.ac.in/noc20_ee03/preview
2. Fuzzy Logic and Neural Networks
https://onlinecourses.nptel.ac.in/noc20_ge09/preview