B.E. (Electrical and Electronics Engineering)

2022 Regulations, Curriculum & Syllabi

(Candidates admitted during Academic Year 2022-2023)

Stay Ahead

BANNARI AMMAN INSTITUTE OF TECHNOLOGY

An Autonomous Institution Affiliated to Anna University - Chennai • Approved by AICTE • Accredited by NAAC with "A+" Grade

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VISION OF THE DEPARTMENT

- To produce competent Electrical and Electronics Engineers to fulfill the industry and society needs.

MISSION OF THE DEPARTMENT

- To provide a unique environment with facilities to inculcate self-learning and to meet the challenges in the field of electrical, electronics, and allied engineering.
- To enhance the knowledge and skills of students, members of faculty and supporting staff through professional training.
- To strengthen academia and industry collaboration for improving the problem solving, interpersonal and entrepreneur skills.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

On successful completion of four year BE degree programme quite a few years after graduationour graduates will:

- PEO1: Apply, analyze, design and create products and provide solutions in the field of Electrical and Electronics Engineering.
- PEO2: Involve in multidisciplinary teams and apply the knowledge and skills of Electrical and Electronics Engineering to create sustainable solutions for global, environmental and communal needs in an ethical way.
- PEO3: Engage in lifelong learning to work in core domain / software / pursue higher studies /research / entrepreneur.

PROGRAMME OUTCOMES (POs)

Engineering Graduates will be able to:

a. **PO1: Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

b. **PO2: Problem Analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

c. **PO3: Design/ Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

d. **PO4: Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of theinformation to provide valid conclusions.

e. **PO5: 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.

f. **PO6: 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 theprofessional engineering practice.

g. **PO7: 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.

h. **PO8: Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and normsof the engineering practice.

i. **PO9: Individual and Team Work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

j. **PO10: 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.

k. **PO11: 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.

l. **PO12: 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.

PROGRAMME SPECIFIC OUTCOMES (PSOs)

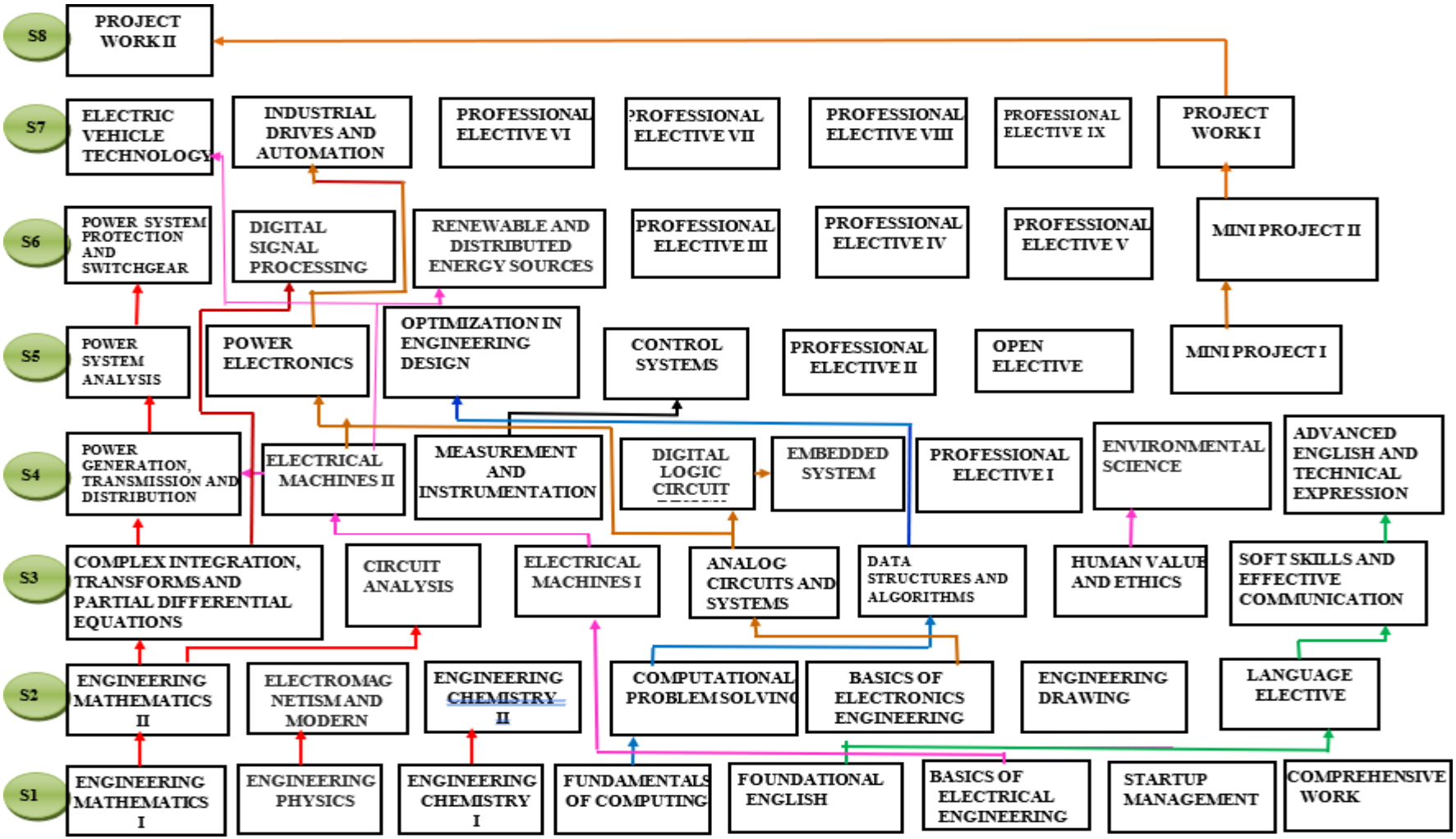
I. **PSO1:** Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

II. **PSO2:** Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

MAPPING OF PEOs AND POs

PEO(s)	Programme Outcome(s)												Programme Specific Outcome(s)	
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	I	II
I	X	X	X	X	X		X	X	X	X		X	X	X
II	X		X	X	X	X		X	X	X	X			X
III	X	X		X		X	X				X	X	X	

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING



DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

Minimum Credits to be Earned : 163

I SEMESTER

Code No.	Course	L	T	P	C	Hours/ Week	Maximum Marks			Category
							CA	ESE	Total	
22MA101	ENGINEERING MATHEMATICS I	3	1	0	4	4	40	60	100	BS
22PH102	ENGINEERING PHYSICS	2	0	2	3	4	50	50	100	BS
22CH103	ENGINEERING CHEMISTRY I	2	0	2	3	4	50	50	100	BS
22GE001	FUNDAMENTALS OF COMPUTING	3	0	0	3	3	40	60	100	ES
22HS001	FOUNDATIONAL ENGLISH	1	0	2	2	3	100	0	100	HSS
22GE003	BASICS OF ELECTRICAL ENGINEERING	2	0	2	3	4	50	50	100	ES
22HS002	STARTUP MANAGEMENT	1	0	2	2	3	100	0	100	EEC
22EE108	COMPREHENSIVE WORK	0	0	2	1	2	100	0	100	EEC
Total		**14**	**1**	**12**	**21**	**27**	**530**	**270**	**800**	**-**

II SEMESTER

Code No.	Course	L	T	P	C	Hours/ Week	Maximum MaPHrks			Category
							CA	ESE	Total	
22MA201	ENGINEERING MATHEMATICS II	3	1	0	4	4	40	60	100	BS
22PH203	ELECTROMAGNETISM AND MODERN PHYSICS	2	0	2	3	4	50	50	100	BS
22CH203	ENGINEERING CHEMISTRY II	2	0	2	3	4	50	50	100	BS
22GE002	COMPUTATIONAL PROBLEM SOLVING	3	0	0	3	3	40	60	100	ES
22GE004	BASICS OF ELECTRONICS ENGINEERING	2	0	2	3	4	50	50	100	ES
22GE005	ENGINEERING DRAWING	1	0	2	2	3	100	0	100	ES
	LANGUAGE ELECTIVE	1	0	2	2	3	100	0	100	HSS
*22HS003	தமிழர் மரபு / Heritage of Tamils	1	0	0	1	2	100	0	100	HSS
Total		**15**	**1**	**10**	**21**	**27**	**530**	**270**	**800**	**-**

* The lateral entry students have to complete this course during IV semester.

III SEMESTER										
Code No.	**Course**	**L**	**T**	**P**	**C**	**Hours/ Week**	**Maximum Marks**			**Category**
							CA	**ESE**	**Total**	
22EE301	COMPLEX INTEGRATION, TRANSFORMS AND PARTIAL DIFFERENTIAL EQUATIONS	3	1	0	4	4	40	60	100	BS
22EE302	CIRCUIT ANALYSIS	3	1	0	4	4	40	60	100	ES
22EE303	ELECTRICAL MACHINES I	3	1	0	4	4	40	60	100	PC
22EE304	ANALOG CIRCUITS AND SYSTEMS	3	0	2	4	5	50	50	100	PC
22EE305	DATA STRUCTURES AND ALGORITHMS	2	0	2	3	4	50	50	100	PC
22HS004	HUMAN VALUES AND ETHICS	2	0	0	2	2	100	0	100	HSS
22HS005	SOFT SKILLS AND EFFECTIVE COMMUNICATION	1	0	0	1	2	100	0	100	EEC
22HS006	தமழரம ததழிலநாடப்பரமம் /	0	0	2	1	2	100	0	100	HSS
Total		**17**	**3**	**8**	**23**	**27**	**530**	**270**	**800**	**-**

IV SEMESTER										
Code No.	**Course**	**L**	**T**	**P**	**C**	**Hours/ Week**	**Maximum Marks**			**Category**
							CA	**ESE**	**Total**	
22EE401	POWER GENERATION, TRANSMISSION AND DISTRIBUTION	3	1	0	4	4	40	60	100	PC
22EE402	ELECTRICAL MACHINES II	3	0	2	4	5	50	50	100	PC
22EE403	MEASUREMENT AND INSTRUMENTATION	3	0	2	4	5	50	50	100	PC
22EE404	DIGITAL LOGIC CIRCUIT DESIGN	3	0	2	4	5	50	50	100	PC
22EE405	EMBEDDED SYSTEMS	3	0	2	4	5	50	50	100	PC
	PROFESSIONAL ELECTIVE I	3	0	0	3	3	40	60	100	PE
22HS007	ENVIRONMENTAL SCIENCE	2	0	0	-	2	100	0	100	HSS
22HS008	ADVANCED ENGLISH AND TECHNICAL EXPRESSION	0	0	2	1	2	100	0	100	EEC
Total		**20**	**1**	**10**	**24**	**31**	**480**	**320**	**800**	**-**

V SEMESTER										
Code No.	**Course**	**L**	**T**	**P**	**C**	**Hours/ Week**	**Maximum Marks**			**Category**
							CA	**ESE**	**Total**	
22EE501	POWER SYSTEM ANALYSIS	3	0	2	4	5	50	50	100	PC
22EE502	POWER ELECTRONICS	3	0	2	4	5	50	50	100	PC
22EE503	OPTIMIZATION IN ENGINEERING DESIGN	3	1	0	4	4	40	60	100	PC
22EE504	CONTROL SYSTEMS	3	1	0	4	4	40	60	100	PC
	PROFESSIONAL ELECTIVE II	3	0	0	3	3	40	60	100	PE
	OPEN ELECTIVE	3	0	0	3	3	40	60	100	PE
22EE507	MINI PROJECT I	0	0	2	1	2	100	0	100	EEC
Total		**18**	**2**	**6**	**23**	**26**	**360**	**340**	**700**	**-**
VI SEMESTER										
Code No.	**Course**	**L**	**T**	**P**	**C**	**Hours/ Week**	**Maximum Marks**			**Category**
							CA	**ESE**	**Total**	
22EE601	POWER SYSTEMS PROTECTION AND SWITCHGEAR	3	0	0	3	3	40	60	100	PC
22EE602	DIGITAL SIGNAL PROCESSING	3	1	0	4	4	40	60	100	PC
22EE603	RENEWABLE AND DISTRIBUTED ENERGY SOURCES	2	0	2	3	3	50	50	100	PC
	PROFESSIONAL ELECTIVE III	3	0	0	3	3	40	60	100	PE
	PROFESSIONAL ELECTIVE IV	3	0	0	3	3	40	60	100	PE
	PROFESSIONAL ELECTIVE V / OPEN ELECTIVE	3	0	0	3	3	40	60	100	PE
22EE607	MINI PROJECT II	0	0	2	1	2	100	0	100	EEC
Total		**17**	**1**	**4**	**20**	**21**	**350**	**350**	**700**	**-**

VII SEMESTER										
Code No.	**Course**	**L**	**T**	**P**	**C**	**Hours/ Week**	**Maximum Marks**			**Category**
							CA	**ESE**	**Total**	
22EE701	ELECTRIC VEHICLE TECHNOLOGY	3	0	0	3	3	40	60	100	PC
22EE702	INDUSTRIAL DRIVES AND AUTOMATION	3	0	2	4	5	50	50	100	PC
	PROFESSIONAL ELECTIVE VI	3	0	0	3	3	40	60	100	PE
	PROFESSIONAL ELECTIVE VII	3	0	0	3	3	40	60	100	PE
	PROFESSIONAL ELECTIVE VIII	3	0	0	3	3	40	60	100	PE
	PROFESSIONAL ELECTIVE IX	3	0	0	3	3	40	60	100	PE
22EE707	PROJECT WORK I	0	0	4	2	4	60	40	100	EEC
Total		**18**	**0**	**6**	**21**	**24**	**310**	**390**	**700**	**-**
VIII SEMESTER										
Code No.	**Course**	**L**	**T**	**P**	**C**	**Hours/ Week**	**Maximum Marks**			**Category**
							CA	**ESE**	**Total**	
22EE801	PROJECT WORK II	0	0	20	10	20	60	40	100	EEC
Total		**0**	**0**	**20**	**10**	**20**	**60**	**40**	**100**	**-**

ELECTIVES										
LANGUAGE ELECTIVES										
Code No.	**Course**	**L**	**T**	**P**	**C**	**Hours / Week**	**Maximum Marks**			**Category**
							CA	**ES**	**Total**	
22HS201	COMMUNICATIVE ENGLISH II	1	0	2	2	3	100	0	100	HSS
22HSH01	HINDI	1	0	2	2	3	100	0	100	HSS
22HSG01	GERMAN	1	0	2	2	3	100	0	100	HSS
22HSJ01	JAPANESE	1	0	2	2	3	100	0	100	HSS
22HSF01	FRENCH	1	0	2	2	3	100	0	100	HSS

PROFESSIONAL ELECTIVES										
VERTICAL I - POWER SYSTEMS										
22EE001	POWER SYSTEM OPERATION AND CONTROL	3	0	0	3	3	40	60	100	PE
22EE002	POWER QUALITY	3	0	0	3	3	40	60	100	PE
22EE003	HIGH VOLTAGE TRANSMISSION	3	0	0	3	3	40	60	100	PE
22EE004	DEMAND SIDE MANAGEMENT	3	0	0	3	3	40	60	100	PE
22EE005	SMART GRID TECHNOLOGIES	3	0	0	3	3	40	60	100	PE
22EE006	POWER SYSTEM DEREGULATION	3	0	0	3	3	40	60	100	PE
VERTICAL II - POWER ELECTRONICS AND DRIVES										
22EE007	ADVANCED POWER SEMICONDUCTOR DEVICES	3	0	0	3	3	40	60	100	PE
22EE008	ADVANCED POWER CONVERTERS	3	0	0	3	3	40	60	100	PE
22EE009	MODERN RECTIFIERS AND RESONANT CONVERTERS	3	0	0	3	3	40	60	100	PE
22EE010	ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY	3	0	0	3	3	40	60	100	PE
22EE011	ELECTRIC DRIVES AND CONTROL	3	0	0	3	3	40	60	100	PE
22EE012	POWER ELECTRONIC INTERFACES FOR RENEWABLE ENERGY SOURCES	3	0	0	3	3	40	60	100	PE
VERTICAL III - ELECTRIC VEHICLE TECHNOLOGY										
22EE013	ELECTRIC VEHICLE ARCHITECTURE	3	0	0	3	3	40	60	100	PE
22EE014	DESIGN OF MOTOR AND POWER CONVERTERS FOR ELECTRIC VEHICLES	3	0	0	3	3	40	60	100	PE
22EE015	ELECTRIC VEHICLE DESIGN, MECHANICS AND CONTROL	3	0	0	3	3	40	60	100	PE
22EE016	DESIGN OF ELECTRIC VEHICLE CHARGING SYSTEM	3	0	0	3	3	40	60	100	PE
21EE017	GRID INTEGRATION OF ELECTRIC VEHICLES	3	0	0	3	3	40	60	100	PE
21EE018	INTELLIGENT CONTROL OF ELECTRIC VEHICLES	3	0	0	3	3	40	60	100	PE
VERTICAL IV - GREEN ENERGY TECHNOLOGY										
22EE019	SOLAR ENERGY CONVERSION SYSTEMS	3	0	0	3	3	40	60	100	PE
22EE020	WIND POWER TECHNOLOGY	3	0	0	3	3	40	60	100	PE
22EE021	FUEL CELL SYSTEMS	3	0	0	3	3	40	60	100	PE

22EE022	RENEWABLE ENERGY SYSTEMS INSTALLATIONS AND MAINTENANCE	3	0	0	3	3	40	60	100	PE
22EE023	ENERGY STORAGE SYSTEMS	3	0	0	3	3	40	60	100	PE
22EE024	GRID INTEGRATION OF RENEWABLE SOURCES	3	0	0	3	3	40	60	100	PE
VERTICAL V - EMBEDDED SYSTEM DESIGN										
22EE025	ADVANCED PROCESSOR ARCHITECTURES	3	0	0	3	3	40	60	100	PE
22EE026	COMMUNICATION PROTOCOLS AND STANDARDS	3	0	0	3	3	40	60	100	PE
22EE027	EMBEDDED C PROGRAMMING	3	0	0	3	3	40	60	100	PE
22EE028	REAL TIME OPERATING SYSTEMS	3	0	0	3	3	40	60	100	PE
22EE029	EMBEDDED LINUX	3	0	0	3	3	40	60	100	PE
22EE030	VIRTUAL INSTRUMENTATION IN EMBEDDED SYSTEMS	3	0	0	3	3	40	60	100	PE
VERTICAL VI - ELECTRICAL TECHNOLOGY										
22EE031	UTILIZATION OF ELECTRICAL ENERGY	3	0	0	3	3	40	60	100	PE
22EE032	INDUSTRIAL ELECTRONICS	3	0	0	3	3	40	60	100	PE
22EE033	ILLUMINATION ENGINEERING	3	0	0	3	3	40	60	100	PE
22EE034	ELECTRICAL SAFETY	3	0	0	3	3	40	60	100	PE
22EE035	ENERGY AUDITING AND MANAGEMENT	3	0	0	3	3	40	60	100	PE
22EE036	PLC AND SCADA	3	0	0	3	3	40	60	100	PE
22EE037	ARTIFICIAL INTELLIGENCE IN ELECTRICAL ENGINEERING	3	0	0	3	3	40	60	100	PE
22EE038	BIG DATA ANALYTICS FOR SMART GRID	3	0	0	3	3	40	60	100	PE
22EE039	INDUSTRY 4.0	3	0	0	3	3	40	60	100	PE

HONOURS DEGREE (With Specialization)										
VERTICAL III - ELECTRIC VEHICLE TECHNOLOGY										
22EEH01	ELECTRIC VEHICLE ARCHITECTURE	2	0	2	3	3	40	60	100	PE
22EEH02	DESIGN OF MOTOR AND POWER CONVERTERS FOR ELECTRIC VEHICLES	3	0	0	3	3	40	60	100	PE
22EEH03	ELECTRIC VEHICLE DESIGN, MECHANICS AND CONTROL	3	0	0	3	3	40	60	100	PE
22EEH04	DESIGN OF ELECTRIC VEHICLE CHARGING SYSTEM	3	0	0	3	3	40	60	100	PE
22EEH05	GRID INTEGRATION OF ELECTRIC VEHICLES	3	0	0	3	3	40	60	100	PE
22EEH06	INTELLIGENT CONTROL OF ELECTRIC VEHICLES	3	0	0	3	3	40	60	100	PE

MINOR DEGREE (Other than EEE Students)										
VERTICAL III - ELECTRIC VEHICLE TECHNOLOGY										
22EEM01	ELECTRIC VEHICLE ARCHITECTURE	3	0	0	3	3	40	60	100	PE
22EEM02	DESIGN OF MOTOR AND POWER CONVERTERS FOR ELECTRIC VEHICLES	3	0	0	3	3	40	60	100	PE
22EEM03	ELECTRIC VEHICLE DESIGN, MECHANICS AND CONTROL	3	0	0	3	3	40	60	100	PE
22EEM04	DESIGN OF ELECTRIC VEHICLE CHARGING SYSTEM	3	0	0	3	3	40	60	100	PE
22EEM05	GRID INTEGRATION OF ELECTRIC VEHICLES	3	0	0	3	3	40	60	100	PE
22EEM06	INTELLIGENT CONTROL OF ELECTRIC VEHICLES	3	0	0	3	3	40	60	100	PE

ONE CREDIT COURSES										
22EE0XA	INTEGRATED CIRCUITS FOR POWER MANAGEMENT	1	0	0	1	-	100	0	100	EEC
22EE0XB	VISIONARY AUTOMATION	1	0	0	1	-	100	0	100	EEC
22EE0XC	SOLAR PV SYSTEM DESIGN AND IMPLEMENTATION	1	0	0	1	-	100	0	100	EEC
22EE0XD	LOW POWERED INDUSTRIAL EDGE AGENT	1	0	0	1	-	100	0	100	EEC

OPEN ELECTIVES										
Code No.	**Course**	**L**	**T**	**P**	**C**	**Hours/ Week**	**Maximum Marks**			**Category**
							CA	**ES**	**Total**	
22OCE01	ENERGY CONSERVATION AND MANAGEMENT	3	0	0	3	3	40	60	100	OE
22OCS01	OBJECT ORIENTED PROGRAMMING	3	0	0	3	3	40	60	100	OE
22OCS02	JAVA FUNDAMENTALS	3	0	0	3	3	40	60	100	OE
22OCS03	KNOWLEDGE DISCOVERY IN DATABASES	3	0	0	3	3	40	60	100	OE
22OCS04	E-LEARNING TECHNIQUES	3	0	0	3	3	40	60	100	OE
22OCS 05	SOCIAL TEXT AND MEDIA ANALYTICS	3	0	0	3	3	40	60	100	OE
22OEC01	BASICS OF ANALOG AND DIGITAL ELECTRONICS	3	0	0	3	3	40	60	100	OE
22OEC02	MICROCONTROLLER PROGRAMMING	3	0	0	3	3	40	60	100	OE
22OEC03	PRINCIPLES OF COMMUNICATION SYSTEMS	3	0	0	3	3	40	60	100	OE
22OEC04	PRINCIPLES OF COMPUTER COMMUNICATION AND NETWORKS	3	0	0	3	3	40	60	100	OE
22OEI01	PROGRAMMABLE LOGIC CONTROLLER	3	0	0	3	3	40	60	100	OE

22OEI02	SENSOR TECHNOLOGY	3	0	0	3	3	40	60	100	OE
22OEI03	FUNDAMENTALS OF VIRTUAL INSTRUMENTATION	3	0	0	3	3	40	60	100	OE
22OEI04	OPTOELECTRONICS AND LASER INSTRUMENTATION	3	0	0	3	3	40	60	100	OE
22OME01	DIGITAL MANUFACTURING	3	0	0	3	3	40	60	100	OE
22OME02	INDUSTRIAL PROCESS ENGINEERING	3	0	0	3	3	40	60	100	OE
22OME03	MAINTENANCE ENGINEERING	3	0	0	3	3	40	60	100	OE
22OME04	SAFETY ENGINEERING	3	0	0	3	3	40	60	100	OE
22OBT01	BIOFUELS	3	0	0	3	3	40	60	100	OE
22OFD01	TRADITIONAL FOODS	3	0	0	3	3	40	60	100	OE
22OFD02	FOOD LAWS AND REGULATIONS	3	0	0	3	3	40	60	100	OE
22OFD03	POST-HARVEST TECHNOLOGY OF FRUITS AND VEGETABLES	3	0	0	3	3	40	60	100	OE
22OFD04	CEREAL, PULSES AND OIL SEED TECHNOLOGY	3	0	0	3	3	40	60	100	OE
22OFT01	FASHION CRAFTSMANSHIP	3	0	0	3	3	40	60	100	OE
22OFT02	INTERIOR DESIGN IN FASHION	3	0	0	3	3	40	60	100	OE
22OFT03	SURFACE ORNAMENTATION	3	0	0	3	3	40	60	100	OE
22OPH01	NANOMATERIALS SCIENCE	3	0	0	3	3	40	60	100	OE
22OPH02	SEMICONDUCTOR PHYSICS AND DEVICES	3	0	0	3	3	40	60	100	OE
22OPH03	APPLIED LASER SCIENCE	3	0	0	3	3	40	60	100	OE
22OPH04	BIO-PHOTONICS	3	0	0	3	3	40	60	100	OE
22OPH05	PHYSICS OF SOFT MATTER	3	0	0	3	3	40	60	100	OE
22OCH01	CORROSION SCIENCE AND ENGINEERING	3	0	0	3	3	40	60	100	OE
22OCH02	POLYMER SCIENCE	3	0	0	3	3	40	60	100	OE
22OCH03	ENERGY STORING DEVICES	3	0	0	3	3	40	60	100	OE
22OMA01	GRAPH THEORY AND COMBINATORICS	3	0	0	3	3	40	60	100	OE
22OGE01	PRINCIPLES OF MANAGEMENT	3	0	0	3	3	40	60	100	OE
22OGE02	ENTREPRENEURSHIP DEVELOPMENT I	3	0	0	3	3	40	60	100	OE
22OGE03	ENTREPRENEURSHIP DEVELOPMENT II	3	0	0	3	3	40	60	100	OE
22OGE04	NATION BUILDING: LEADERSHIP AND SOCIAL RESPONSIBILITY	3	0	0	3	3	40	60	100	OE
22OAM01	COMPUTER VISION IN HEALTHCARE APPLICATION	3	0	0	3	3	40	60	100	OE
22OAM02	NEURAL NETWORKS	3	0	0	3	3	40	60	100	OE

22MA101 ENGINEERING MATHEMATICS I 3 1 0 4

Course Objectives

- To impart mathematical modeling to describe and explore real-world phenomena and data.
- To provide basic understanding on Linear, quadratic, power and polynomial, exponential, and multi variable models
- Summarize and apply the methodologies involved in framing the real world problems related to fundamental principles of polynomial equations

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

d. PO4.Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

Course Outcomes (COs)

1. Implement the concepts of mathematical modeling based on linear functions in Engineering.
2. Formulate the real-world problems as a quadratic function model
3. Demonstrate the real-world phenomena and data into Power and Polynomial functions
4. Apply the concept of mathematical modeling of exponential functions in Engineering
5. Develop the identification of multivariable functions in the physical dynamical problems

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	2	2	1									2	
2	2	2	2	1									2	1
3	3	2	2	1									2	1
4	2	2	2	1									2	1
5	2	2	2	1									2	1

UNIT I **9 Hours**

MATHEMATICS MODELING OF LINEAR FUNCTIONS

The geometry of linear equations - Formation of linear equations: Method of least squares and method of regression - Vector spaces: Basic concepts with examples - Linear combination - Eigen values and vectors

UNIT II **9 Hours**

MATHEMATICAL MODELING OF QUADRATIC FUNCTIONS

General form of a quadratic function - Basic relationships between the equation and graph of a quadratic function - Sum of squares error and the quadratic function of best fit - Quadratic forms: Matrix form - Orhtogonality - Canonical form and its nature

UNIT III **9 Hours**

MATHEMATICAL MODELING OF POWER AND POLYNOMIAL FUNCTIONS

Characteristics of the graphs of power and polynomial functions - Fitting of power and polynomial functions using the method of least squares - Local maxima and local minima of power and polynomial functions - Power series of functions with real variables, Taylors series, radius and interval of convergence - Tests of convergence for series of positive terms - comparison test, ratio test

UNIT IV **9 Hours**

MATHEMATICAL MODELING OF EXPONENTIAL FUNCTIONS

Concept of exponential growth - Graphs of exponential functions - Relationship between the growth factor and exponential growth or decline - Exponential equations have a variable as an exponent and take the form y = abx through least square approximation - Calculus of exponential functions - Exponential series - Characteristics

UNIT V **9 Hours**

MATHEMATICAL MODELING OF MULTIVARIABLE FUNCTIONS

Graphing of functions of two variables - Partial derivatives - Total derivatives - Jacobians - Optimization of multivariable functions with constraints - Optimization of multivariable functions without constraints

Total: 60 Hours

Reference(s)

1. Erwin Kreyszig, Advanced Engineering Mathematics, Tenth Edition, Wiley India Private Limited, New Delhi 2016
2. B. S. Grewal, Numerical Methods in Engineering & Science: With Programs in C, C++ & MATLAB, Khanna, 2014
3. S.C. Gupta, V.K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand & Sons2020
4. Thomas and Finney, Calculus and analytic Geometry, Fourteenth Edition, By Pearson Paperback, 2018

22PH102 ENGINEERING PHYSICS 2 0 2 3

Course Objectives

- Understand the concept and principle of energy possessed by mechanical system
- Exemplify the propagation and exchange of energy
- Identify the properties of materials based on the energy possession

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
i. Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

Course Outcomes (COs)

1. Illustrate the concept and principles of energy to understand mechanical systems
2. Exemplify the types of mechanical oscillations based on vibrational energy
3. Infer the concept of propagation of energy as transverse and longitudinal waves
4. Analyze the exchange of energy and work between the systems using thermodynamic principles
5. Apply the concept of energy and entropy to understand the mechanical properties of materials

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	1							2					
2	2	1							2					
3	2	1							2					
4	2	1							2					
5	2	1							2					

UNIT I **6 Hours**

CONSERVATION OF ENERGY

Concept of energy - types of energy-conservation of energy. Mechanical energy: - translation - rotation -vibration - Kinetic and potential energies - conservation - work and energy - laws of motion - minimization of potential energy - equilibrium - dissipative systems - friction

UNIT II **5 Hours**

VIBRATIONAL ENERGY

Periodic Motion - Simple Harmonic Motion - Energy of the SHM - Pendulum types - Damped oscillations - forced oscillations - natural frequency - resonance

UNIT III **6 Hours**

PROPAGATION OF ENERGY

Transfer of energy - material medium - Transverse wave - Longitudinal wave - standing wave - interference - Doppler effect. Sound waves and its types - characteristics - human voicere - reflection - refraction-beats

UNIT IV **7 Hours**

EXCHANGE OF ENERGY

Energy in transit - heat - Temperature - measurement - specific heat capacity and water - thermal expansion - Heat transfer processes. Thermodynamics: Thermodynamic systems and processes - Laws of thermodynamics - Entropy - entropy on amicroscopic scale -maximization of entropy.

UNIT V **6 Hours**

ENERGY IN MATERIALS

Elastic energy - Structure and bonding - Stress - strain - Tension and compression - elastic limit - Elastic Modulus - Stress - strain diagram - ductility - brittleness - rubber elasticity and entropy

1 **5 Hours**

EXPERIMENT 1

Determination of resultant of system of concurrent coplanar forces-Parallelogram law of forces

2 **5 Hours**

EXPERIMENT 2

Determination of moment of inertia-Torsional pendulum

3 **5 Hours**

EXPERIMENT 3

Determination of thickness of a thin wire using interference of light-Air wedge method

4 **4 Hours**

EXPERIMENT 4

Determination of ac frequency using Meldes apparatus

5 **3 Hours**

EXPERIMENT 5

Determination of thermal conductivity of a bad conductor using Lees disc method

6 **4 Hours**

EXPERIMENT 6

Determine the
(i) wavelength of ultrasonics in a liquid medium,
(ii) velocity of ultrasonic waves in the given liquid
(iii) compressibility of the given liquid using ultrasonic interferometer

7 **4 Hours**

EXPERIMENT 7

Determination of Youngs modulus of a given material- Non uniform bending method

Total: 60 Hours

Reference(s)

1. C J Fischer, The energy of Physics Part I: Classical Mechanics and Thermodynamics, Cognella Academic Publishing, 2019.
2. P G Hewitt, Conceptual Physics, Pearson education, 2017
3. R A Serway and J W Jewitt, Physics for Scientists and Engineers, Thomson Brooks/Cole, 2019
4. J Walker, D Halliday and R Resnick, Principles of Physics, John Wiley and Sons, Inc, 2018
5. H C Verma, Concepts of Physics (Vol I & II), Bharathi Bhawan Publishers & Distributors, New Delhi, 2017

22CH103 ENGINEERING CHEMISTRY I 2 0 2 3

Course Objectives

- Understand the origin of elements from the universe
- Outline the properties of elements in the periodic table
- Analyse the different types of bond formed during chemical reactions and its reaction thermodynamics
- Summarize different states of matter based on atomic arrangement

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

i. PO9.Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

j. PO10.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

l. PO12.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.

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

Course Outcomes (COs)

1. Understand nuclear transmutation reactions that lead to the formation of elements in the universe
2. Illustrate atomic structure of elements in the periodic table and interpret the periodic trends in properties of elements with its anomaly
3. Apply the conditions for the formation of different types of chemical bonds and predict the minimum energy required for a reaction to occur
4. Analyse endothermic and exothermic processes and exchange of energy during chemical reactions
5. Analyse whether the given matter is a solid, liquid, gas, or plasma and interpret the arrangement of atoms

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	1							-	-			-	
2	2	1							-	-			-	
3	2	1							-	-			-	
4	2	1							-	-		-		
5	2	1							-	-			-	

UNIT I **5 Hours**

ORIGIN OF ELEMENTS

Hydrogen - Elements and Sun - fusion - hypernova - supernova - dying stars - man-made elements

UNIT II **7 Hours**

ATOMIC STRUCTURE AND PERIODICITY

Atomic Structure - Electronic configuration - Periodic Table - Periodic trends in properties of elements - Anomalous behaviour in periodicity

UNIT III **6 Hours**

CHEMICAL BONDING

Octet rule & its limitations - types of chemical bonds - bond energy - bond cleavage - activation energy of reactions

UNIT IV **6 Hours**

REACTION THERMODYNAMICS

Conservation of energy - Endothermic reactions & exothermic reactions - Exchange of energy involved in chemical reactions

UNIT V **6 Hours**

STATES OF MATTER

Solid - liquid - gas - plasma - arrangement of atoms/ions/molecules in different phases

1 **2 Hours**

EXPERIMENT 1

Lab safety rules and guidelines for students - OSHA Guidelines

2 **3 Hours**

EXPERIMENT 2

Estimation of dissolved oxygen content in water sample(s) by Winkler's method

3 **4 Hours**

EXPERIMENT 3

Determination of Fe(II) in a sample using spectrophotometer

4 **3 Hours**

EXPERIMENT 4

Estimation of chromium content in water sample by volumetric analysis

5 **3 Hours**

EXPERIMENT 5

Estimation of chloride present in the given water sample by argentometric method

6 **3 Hours**

EXPERIMENT 6

Conductometric titration of mixture of acids

7 **4 Hours**

EXPERIMENT 7

Estimation of magnesium ions in given solution by EDTA method.

8 **4 Hours**

EXPERIMENT 8

Preparation of salt of fatty acid by saponification process

9 **4 Hours**

EXPERIMENT 9

Recrystallization of aspirin from water/ethanol

Total: 60 Hours

Reference(s)

1. Peter Atkins, Physical Chemistry, Oxford university press, 2019
2. Rose Marie Gallagher and Author Paul Ingram, Complete Chemistry Cambridge IGCSE, Oxford university press, 2020
3. P L Soni, Text book of inorganic chemistry, Chand publishers, New Delhi, 2017
4. J.D. Lee, Concise inorganic chemistry, Blackman Science Ltd, France, Wiley-India, 5th edition (Reprint), 2016
5. Gareth Price, Thermodynamics of chemical processes, Oxford university press, 2019
6. D Tabor, Gases, liquids and solids and other states of matter, Oxford University press, 2018

22GE001 FUNDAMENTALS OF COMPUTING 3 0 0 3

Course Objectives

- Understand the fundamental digital logics behind computations of computer systems.
- Develop simple assembly language programs with respect to arithmetic operations.
- Understand the program execution process and basics of software development methodologies.

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

Course Outcomes (COs)

1. Infer the hidden languages and inner structures of computer hardware and software through codes and combinations.
2. Interpret the organizational and architectural issues of a digital computer with concepts of various data transfer techniques in digital computers and the I/O interfaces.
3. Analyze programming problems and apply assembly instructions to solve simple problems.
4. Infer the fundamentals of operating system and System programs basics.
5. Apply the software development methodologies to various real life scenarios.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	2	2										-	
2	2	2	2										-	
3	2	2	2										-	
4	2	2	2										-	
5	2	2	2										-	

UNIT I **8 Hours**

CODES AND COMBINATIONS

Communication using Mores and Braille binary codes - Digitizing letters, numbers and objects using binary codes - Performing simple operations: addition through binary codes.

UNIT II **9 Hours**

COMPUTATION USING COMPUTER

Communication to computing devices through various input sources - Computational operation - its flow, functions and control - communication to output devices - Basic communication protocol.

UNIT III **11 Hours**

ASSEMBLY LANGUAGE PROGRAMMING

Little Man Computing (LMC) Model - Instruction Set - Labels - Calculation -Branching - Input- Output - Loops - Simple programs.

UNIT IV **9 Hours**

OPERATING SYSTEM AND APPLICATION GENERATION

BIOS - Device Drivers - Resources - Scheduler - Applications Generation and Creation - Stages of Compilation - Linkers, Loaders and Libraries.

UNIT V **8 Hours**

SOFTWARE DEVELOPMENT

Phases of application life cycle management - Software Development Methodologies - Web Page development.

Total: 45 Hours

Reference(s)

1. Charles Petzold, "Code: The Hidden Language of Computer Hardware and Software", Microsoft Press books, 2009.
2. David D. Riley, Kennya. Hunt, "Computational thinking for the modern problem Solver", CRC Press Taylor & Francis Group, 2014.
3. Andrew Eliaz, "Little Man Computer Programming: For The Perplexed From The Ground Up", The Internet Technical Bookshop; 1st edition, 2016.
4. Abraham Silberschatz, "Peter Baer Galvin and Greg Gagne, Operating System Concepts", 9th Edition, John Wiley & Sons Pvt. Ltd, 2015.
5. Roger S.Pressman, "Software Engineering: A Practitioner"s Approach", McGraw Hill International edition, Seventh edition, 2010

22HS001 FOUNDATIONAL ENGLISH 1 0 2 2

Course Objectives

- Heighten awareness of grammar in oral and written expression
- Improve speaking potential in formal and informal contexts
- Improve reading fluency and increased vocabulary
- Prowess in interpreting complex texts
- Fluency and comprehensibility in self-expression
- Develop abilities as critical readers and writers
- Improve ability to summarize information from longer text, and distinguish between primary and supporting ideas

Course Outcomes (COs)

1. Express themselves in a professional manner using error-free language
2. Express in both descriptive and narrative formats
3. Understand and make effective use of the English Language in Business contexts
4. Actively read and comprehend authentic text
5. Express opinions and communicate experiences.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1									2	3		2		
2									2	3		2		
3									2	3		2		
4									2	3		2		
5									2	3		2		

UNIT I **15 Hours**

SELF-EXPRESSION

Self-Introduction - Recreating Interview Scenarios (with a focus on verbal communication) - Subject Verb Concord - Tenses - Common Errors in verbal communication Be-verbs - Self-Introduction - Recreating interview scenarios - Haptics - Gestures - Proxemics - Facial expressions – Paralinguistic / Vocalic - Body Language - Appearance - Eye Contact – Artefacts Self-Introduction - Powerful openings and closings at the interview - Effective stock phrases - Modified for spontaneity and individuality-Question tags, framing questions including WH Questions - Prepositions - Listening to Ted talks-Listening for specific information

UNIT II **15 Hours**

CREATIVE EXPRESSION

Descriptive Expression - Picture Description and Blog Writing - Vocabulary - One word substitution - Adjectives - Similes, Metaphors, Imagery & Idioms - Link words - Inclusive language Narrative Expression - Travelogue and Minutes of Meeting -Verbal analogy -Sequence & Time order words - Jumbled paragraph, sentences, Sequencing - Text & Paragraph completion - Past tense - Using quotation marks

UNIT III **15 Hours**

FORMAL EXPRESSION

Formal Letters and Emails - Writing: E-mails and Letters of apology, Requisition and Explanation, and Letters to Newspapers - Speaking: Tendering verbal apologies, and explanations, persuading a listener/ audience-Hierarchy in

Business correspondence- Subject of a mail, Header, Body (Salutation) and Footer of a mail.Conjunctional clause Punctuation - Formal Idioms - Phrases - Articles - Definite & Indefinite - Types of sentences - Modal verbs Precision in comprehension, Summary writing, Selective summary - Reading: Active reading - short paragraphs, excerpts, articles and editorials - Skimming and Scanning Reading comprehension & analysis - Tenses, QP/ PQ approach. Identifying the central themes/ crux-Interpreting tone - formal/informal/semi-formal - Note - taking - Listening: Listening for data, for specific information, for opinion -Active and passive Listening - Transcription - Paraphrasing and summarising information-Agreeing & disagreeing - Note - taking - Writing: Summary writing, selective summary, paraphrasing, note - making, opinion pieces - Finding synonyms in the context Paraphrasing - Sentence Transformation - simple, compound, complex. Sentence substitution - Sentence completion-Interpreting paragraphs.

Total: 45 Hours

Reference(s)

1. Sasikumar, V, et.al. A Course in Listening & Speaking Foundation Books, 2005.
2. Murphy, Raymond. English Grammar in Use: A Self-Study Reference and Practice Book for IntermediateStudents: with Answers. Cambridge: Cambridge University Press, 1985.
3. Prasad, Hari Mohan. A Handbook of Spotting Errors. Mcgraw Hill Education, 2010
4. Reynolds, John. Cambridge IGCSEÃ‚Â® First Language English. 2018th ed., Hodder Education, 2018.
5. Wiggins, Grant P., and Jay McTighe. Understanding by Design. Association for Supervision and CurriculumDevelopment, 2008.

22GE003 BASICS OF ELECTRICAL ENGINEERING 2 0 2 3

Course Objectives

- To understand the basic concepts of electrical charge and its properties
- To interpret the formation of electric field due to electric charges
- To illustrate the concept of magnetic fields due to revolving electron
- To illustrate the force on moving charges in electric and magnetic field
- To understand the energy transfer in electro mechanical conversion

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems
b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences
c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
d. PO4.Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions
m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.
n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Interpret the behavior of electric charges in different medium using coulombs law.
2. Analyse the electric field due to different charge distributions.
3. Analyse the magnetic field intensity due to long conductor, solenoid, toroid and magnetic dipoles.
4. Analyze the force on conductors due to the moving charges.
5. Interpret the energy conversion concepts in electromagnetic fields.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2	2										2	2
2	2	2	2	3									3	2
3	2	2	1	3									2	2
4	3	2	1	2									2	2
5	2	2											2	2

UNIT I **5 Hours**

ELECTRIC CHARGE

Properties of charge, additivity of charges, quantization of charge, conservation of charge , Forces between multiple charges, Electric charge in conductors, Drift of Electrons, Charges in Clouds.

UNIT II **7 Hours**

ELECTRIC FIELD

Electric field due to system of charges, Significance of Electric field line. Electric Dipole and its significance, Continuous charge distribution, Field in infinite long uniform straight conductors, field in uniform charged uniform infinite plane sheet, field due to uniform thin spherical sheet.

UNIT III **7 Hours**

MAGNETIC FIELDS

Concept of magnetic field, magnetic fields in infinitely long straight wire, straight and toroidal solenoids, Magnetic dipole moment of a revolving electron, Magnetic field intensity due to a magnetic dipole (bar magnet) along its axis and perpendicular to axis, Induced Electric field due to changing Magnetic Field.

UNIT IV **6 Hours**

FORCE ON CHARGES

Force on a moving charge in uniform magnetic and electric fields, Force on a current carrying conductor in a uniform magnetic field, Force between two parallel current carrying conductors.

UNIT V **5 Hours**

ELECTRO MECHANICAL ENERGY CONVERSION

Energy transfer in electromagnetic fields, Energy storage in magnetic field, Electromagnetic induction, induced emf, Eddy currents. Self and mutual inductance Linear Momentum and Angular Momentum carried by Electromagnetic Fields.

1 **15 Hours**

EXPERIMENT 1

Analyze and design of Electromechanical energy conversion system.

2 **15 Hours**

EXPERIMENT 2

Develop an electrical machine and analyze its performance with supplied input of AC from 0 V to 230 V.

Total: 60 Hours

Reference(s)

1. Mathew N. O. Sadiku, Principles of Electromagnetics, 6th Edition, Oxford University 2020
2. William H. Hayt and John A. Buck, Engineering Electromagnetics, McGraw Hill 2020
3. Kraus and Fleisch, Electromagnetics with Applications, McGraw Hill International Editions, 2017
4. S.P.Ghosh, Lipika Datta, Electromagnetic Field Theory, First Edition, McGraw Hill Education(India) Private Limited 2017

22HS002 STARTUP MANAGEMENT **1 0 2 2**

Course Objectives

- Promote entrepreneurial spirit and motivate to build startups
- Provide insights on markets and the dynamics of buyer behaviour
- Train to develop prototypes and refine them to a viable market offering
- Support in developing marketing strategies and financial outlay
- Enable to scale up the porotypes to commercial market offering

Course Outcomes (COs)

1. Generate valid and feasible business ideas
2. Create Business Model Canvas and formulate positioning statement
3. Invent prototypes that fulfills an unmet market need
4. Formulate business strategies and create pitch decks
5. Choose appropriate strategies for commercialization

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1							1	2	1		1			
2							2	2	1	1	2			
3							3	3	1	2	2			
4							1	3	1	2	2			
5							2	3	2	2	2			

UNIT I **3 Hours**

BUSINESS MODELS AND IDEATION

Startups: Introduction, Types of Business Modes for Startups. Ideation: Sources of Ideas, Assessing Ideas, Validating Ideas, Tools for validating ideas, Role of Innovation and Design Thinking

UNIT II **3 Hours**

UNDERSTANDING CUSTOMERS

Buyer Decision Process, Buyer Behaviour, Building Buyer Personas, Segmenting, Targeting and Positioning, Value Proposition (Business Model Canvas), Information Sourcing on Markets, Customer Validation

UNIT III **3 Hours**

DEVELOPING PROTOTYPES

Prototyping: Methods-Paper and Digital, Customer Involvement in Prototyping, Product Design Sprints, Refining Prototypes

UNIT IV **3 Hours**

BUSINESS STRATEGIES AND PITCHING

Design of Marketing Strategies and Campaigns, Go-To-Market Strategy, Financial KPIs Financial Planning and Budgeting, Assessing Funding Alternatives, Pitching, Preparing Pitch Decks

UNIT V **3 Hours**

COMMERCIALIZATION

Implementation: Prototype to Commercialization, Test Markets, Institutional Support, Registration Process, IP Laws and Protection, Legal Requirements, Type of Ownership, Building and Managing Teams, Defining role of investors

1 **1 Hours**

EXPERIMENT 1

Analysis of various business sectors

2 **2 Hours**

EXPERIMENT 2

Developing a Design Thinking Output Chart

3 **1 Hours**

EXPERIMENT 3

Creating Buyer Personas

4 **3 Hours**

EXPERIMENT 4

Undertake Market Study to understand market needs and assess market potential

5 **2 Hours**

EXPERIMENT 5

Preparation of Business Model Canvas

6 **15 Hours**

EXPERIMENT 6

Developing Prototypes

7 **2 Hours**

EXPERIMENT 7

Organizing Product Design Sprints

8 **2 Hours**

EXPERIMENT 8

Preparation of Business Plans

9 **2 Hours**

EXPERIMENT 9

Preparation of Pitch Decks

Total: 45 Hours

Reference(s)

1. Rashmi Bansal, Connect the Dots, Westland and Tranquebar Press, 2012
2. Pavan Soni, Design Your Thinking: The Mindsets, Toolsets and Skill Sets for Creative Problem-solving, Penguin Random House India, 2020
3. Ronnie Screwvala, Dream with Your Eyes Open: An Entrepreneurial Journey, Rupa Publications, 2015
4. Stephen Carter, The Seed Tree: Money Management and Wealth Building Lessons for Teens, Seed Tree Group, 2021
5. Kotler Philip, Marketing Management, Pearson Education India, 15th Edition
6. Elizabeth Verkey and Jithin Saji Isaac, Intellectual Property, Eastern Book Company, 2nd Edition, 2021

22MA201 ENGINEERING MATHEMATICS II 3 1 0 4

Course Objectives

- To impart and analyze the concepts of differential equations to describe in real-world phenomena
- To provide basic understanding on differential equation models and vector field models
- Summarize and apply the methodologies involved in framing the real world problems related to fundamental principles of complex functions

Course Outcomes (COs)

1. Interpret the concept of differential equations through mathematical modeling and analyze its applications in engineering
2. Formulate the real world problems as second order linear differential equations and give solutions for the same
3. Demonstrate the real-world phenomena with magnitude and direction in the form of vector functions
4. Apply the concept of vector fields and line integrals through mathematical modeling in engineering
5. Determine complex functions and apply them to formulate problems arising in engineering

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
1	1	3										
2	2	3										
3	2	3										
4	3	3										
5	3	3										

UNIT I **9 Hours**

FIRST ORDER LINEAR DIFFERENTIAL EQUATIONS

Formation of differential equations- Solutions of first order linear ODE: Leibnitzs and method of separation of variables- Cooling/Heating of an object - A falling object- Modeling of electric circuits: RL and RC circuits - Modeling of population dynamics: Exponential growth and decay - Logistic growth model

UNIT II **9 Hours**

SECOND ORDER LINEAR DIFFERENTIAL EQUATIONS

Methods of solving second order linear ordinary differential equations -Models for linear oscillators: Simple harmonic motion - Mechanical vibrations with and without damping - Electric circuit system: RLC circuits

UNIT III **9 Hours**

VECTOR DIFFERENTIAL CALCULUS

Vector and scalar functions - Fields - Derivative of vector function and geometrical interpretation- Velocity and acceleration - Gradient and its properties- Tangent and normal vectors - Directional derivative- Divergence of a vector field - Curl of a vector field - Projectile motion

UNIT IV **9 Hours**

VECTOR INTEGRAL CALCULUS

Line integrals of vector point functions - Surface integral of vector point functions - Applications of line and surface integrals - Greens theorem in a plane - Stokes theorem - Gauss divergence theorem

UNIT V **9 Hours**

COMPLEX FUNCTIONS

Basic concepts of Complex numbers Geometrical representation of complex number - Analytic functions and its properties - Construction of Analytic functions: Fluid flow Electric flow - Mapping of complex functions

Total: 60 Hours

Reference(s)

1. Richard E. Williamson, Introduction to Differential Equations and Dynamical Systems, McGraw Hill Companies. Inc, 1997
2. Michael Greenberg, Advanced Engineering Mathematics, 2/e, Pearson, 2018
3. George B.Thomas, Maurice D. Weir and Joel Hass Thomas Calculus, 13/e, Pearson Publishers, 2013
4. Erwin Kreyszig, Advanced Engineering Mathematics Wiley, 10th editi5. J. Stewart, Essential Calculus, Cengage, 2nd edition, 2017on ,2015
5. J. Stewart, Essential Calculus, Cengage, 2nd edition, 2017

22PH202 ELECTROMAGNETISM AND MODERN PHYSICS 2 0 2 3

Course Objectives

- Understand the principles and mechanisms of electricity and magnetism
- Infer the classification of electromagnetic waves
- Analyze the theory of relativity and energy bands

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
i. Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

Course Outcomes (COs)

1. Understand the principles and mechanism of electrostatics and current
2. Illustrate the principles and mechanism of magneto statics
3. Classify electromagnetic waves and infer the characteristics of visible light
4. Outline the importance of theory of relativity and analyze the wave nature of particles
5. Exemplify the electrical properties of semiconductor based on the band theory

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	1							2					
2	2	1							2					
3	2	1							2					
4	2	1												
5	2	1							2					

UNIT I **6 Hours**

ELECTRICITY

Electric monopoles - Electric field- Electric flux - Electric potential - electrical energy- capacitor-conductors and insulators-Electric dipole and polarization - electric current -voltage sources- resistance

UNIT II **6 Hours**

MAGNETISM

Sources of magnetism- monopoles-magnetic field and force-magnetic field and current distribution- magnetic dipole-magnetic potential energy-inductor- electric and magnetic field comparison

UNIT III **6 Hours**

ELECTROMAGNETIC WAVES AND LIGHT

Electromagnetism: basic laws-electromagnetic energy-radiation. Electromagnetic waves: origin, nature and spectrum-visible light-Principle of least time- geometrical optics-Human eye - Diffraction - Interference - polarization-LASER

UNIT IV **6 Hours**

MODERN PHYSICS

Special theory of relativity - simultaneity and time dilation - length contraction - relativistic mass variation. Matter

waves - de-Broglie hypothesis - wave nature of particles

UNIT V **6 Hours**

ENERGY BANDS IN SOLIDS

Band theory of solids - classification of materials - semiconductors - direct and indirect semiconductor - fermi energy -Intrinsic and extrinsic semiconductor - carrier concentration - electrical conductivity

1 **5 Hours**

EXPERIMENT 1

Determination of V-I characteristics of a solar cell

2 **5 Hours**

EXPERIMENT 2

Determination of Hall voltage of a given specimen by Hall Effect method

3 **5 Hours**

EXPERIMENT 3

Determination of wavelength of a given laser source - Grating method

4 **4 Hours**

EXPERIMENT 4

Determination of particle size using diode laser

5 **3 Hours**

EXPERIMENT 5

Determination of refractive index of a given solid medium and liquid medium

6 **4 Hours**

EXPERIMENT 6

Determination of energy loss per cycle of a ferromagnetic material using hysteresis curve

7 **4 Hours**

EXPERIMENT 7

Determination of band gap energy of a given semiconducting material

Total: 60 Hours

Reference(s)

1. C J Fischer, The energy of Physics Part II: Electricity and Magnetism, Cognella Academic Publishing, 2019
2. P G Hewitt, Conceptual Physics, Pearson education, 2017
3. R A Serway and J W Jewitt, Physics for Scientists and Engineers, Thomson Brooks/Cole, 2019
4. J Walker, D Halliday and R Resnick, Principles of Physics, John Wiley and Sons, Inc, 2018
5. H C Verma, Concepts of Physics (Vol I & II), Bharathi Bhawan Publishers & Distributors, New Delhi, 2017

22CH203 ENGINEERING CHEMISTRY II 2 0 2 3

Course Objectives

- Understand the concept of electrochemistry for determination of electrode potential, pH and applications asenergy storage devices
- Outline the chemistry of metal corrosion and analyze the methods of corrosion control
- Understand how catalyst increases the reaction rate
- Summarize the variation in properties and reactivity of isotopes

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Apply the electrochemical principles to determine the electrode potential of a metal
2. Analyze the construction, cell reactions and working of energy storage devices
3. Analyze the specific operating conditions under which corrosion occurs and suggest a method to controlcorrosion
4. Illustrate reaction mechanisms and assess the role of catalyst in a chemical reaction
5. Analyze various types of nuclear transmutation including decay reactions

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	2	2										2	2
2	3	2	2										2	2
3	2	2	2										2	2
4	2	2	2										2	2
5	2	2	2										2	2

UNIT I **6 Hours**

ELECTROCHEMISTRY

Origin of potential - electromotive force - electrical double layer - transport of charge within the cell - cell description - prediction of cell potentials

UNIT II **6 Hours**

ENERGY STORING DEVICES

Relation between electrical energy and energy content of a cell - reversible and irreversible cell - charging and discharging reactions in a reversible cell - current challenges in energy storage technologies

UNIT III **6 Hours**

METAL CORROSION AND ITS PREVENTION

Oxidation of metals: Electrochemical origin of corrosion - electromigration - electron transfer in the presence and absence of moisture - galvanic series. Strategies for corrosion control: Galvanic anode and impressed current.

UNIT IV **6 Hours**

CATALYSIS

Energy profile diagram for a chemical reaction - activation energy - role of catalyst - homogeneous and heterogeneous catalysis - types

UNIT V **6 Hours**

NUCLEAR REACTIONS

Radioactive and stable isotopes - Variation in properties between isotopes - Radioactive decay (alpha, beta and gamma) - Half-life period - Nuclear reactions – Radiocarbon dating

1 **4 Hours**

EXPERIMENT 1

Determination of strength of hydrochloric acid in a given solution using pH meter

2 **4 Hours**

EXPERIMENT 2

Application of calomel electrode to determine the redox potential of Fe(II) solution

3 **4 Hours**

EXPERIMENT 3

Construct an electrochemical cell exhibiting valid output and compare its potential with the given standard cell

4 **5 Hours**

EXPERIMENT 4

Determination of corrosion percentage of iron/steel by weight loss method

5 **4 Hours**

EXPERIMENT 5

Determination of percentage of corrosion inhibition in iron/mild steel using a natural inhibitor

6 **4 Hours**

EXPERIMENT 6

Electroplate copper on the given target object and estimate the amount of copper deposited at cathode

7 **5 Hours**

EXPERIMENT 7

Determination of rate constant of acid catalyzed hydrolysis of ester

Total: 60 Hours

Reference(s)

1. Jain and Jain, Engineering Chemistry, 16th Edition, Dhanpat Rai Publishing Company, New Delhi, 2013.
2. P.H. Rieger, Electrochemistry, Second Edition (Reprint), Springer, Netherland, 2012
3. E.McCafferty, Introduction to Corrosion Science, Springer; 2010 Edition, January 2010
4. S. Vairam, Engineering Chemistry, John Wiley &Sons, 2014
5. H.J. Arnikar, Essentials of Nuclear Chemistry, 4th edition, (revised) New Age International Publishers, 2011
6. U. Hanefeld, L. Lefferts, Catalysis: An Integrated Textbook for Students, Wiley- VCH, 2017

22GE002 COMPUTATIONAL PROBLEM SOLVING 3 0 0 3

Course Objectives

- Analyze the algorithm design techniques and development principles in solving the real life problems.
- Illustrate the different ways of organizing and storing the data in computing systems.
- Understand the basic network configuration and setup connections among different device systems.

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

d. PO4.Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

Course Outcomes (COs)

1. Analyze a problem and formulate algorithms, pseudo codes and flowcharts.
2. Develop algorithmic solutions to simple computational problems and explore algorithmic approaches to problem solving.
3. Design and apply appropriate data structures for solving computing problems.
4. Compare the various storage devices used in a computer system.
5. Analyze the requirements for a given organizational structure and establish the connection between two or more computers to form a network.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	2	2	2										
2	2	2	2	2										
3	2	2	2	2										
4	2	2	2	2										
5	2	2	2	2										

UNIT I **6 Hours**

VISUAL PROCESS MODELING

Scenario decomposition - logical sequencing - drawing flowchart - preparing visual process model.

UNIT II **12 Hours**

ALGORITHMIC DESIGN THINKING

Analysis - Verification - Brute force - Divide and conquer - Greedy - Backtracking.

UNIT III **12 Hours**

DATA ORGANIZATION

Elementary Data Organization - Abstract Data Types - Fundamentals of Linear and Non Linear Data Structures.

UNIT IV **7 Hours**

DATA STORAGE

Flat File and Relational database- Data Read & Write in Local Storage, Server Storage and Cloud storage - Database Query Methods.

UNIT V **8 Hours**

NETWORKING ESSENTIALS

Networking Components and Services - IP Addressing - Configuring and Managing the Campus Network - Network Security - Firewalls.

Total: 45 Hours

Reference(s)

1. David D. Riley, Kennya. Hunt, "Computational thinking for the modern problem Solver", CRC Press Taylor & Francis Group, 2014.
2. Anany Levitin, "Introduction to the Design and Analysis of Algorithms", Third Edition, Pearson Education Asia, 2011.
3. Mark Allen Weiss, "Data Structures and Algorithm Analysis in C", 2nd Edition, Pearson Education,2016.
4. Abraham Silberschatz, Henry F. Korth and S. Sudarshan, "Database System Concepts", McGraw Hill, 2015.
5. Behrouz A.Forouzan, "Data Communication and Networking", 5th Edition, Tata McGraw-Hill, 2014.

22GE004 BASICS OF ELECTRONICS ENGINEERING 2 0 2 3

Course Objectives

- To Understand the concept of energy transmission through mechanical, electrical and electromagnetic form.
- To Analyze the use of PN Junction Diode and BJT for signal conditioning.
- To apply the working principle of PN Junction Diode and BJT for the design of basic Digital Logic.
- To analyze the working and characteristics of Special Purpose Semiconductor Electronic Devices.
- Devices.

Programme Outcomes (POs)

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Understand the need for electrical and electromagnetic signal transmission.
2. Analyze the working principle and characteristics of PN junction diode.
3. Analyze the working principle and characteristics of Bipolar Junction Transistor.
4. Apply the working principle of PN Junction diode and BJT for designing basic Digital Logic functions.
5. Analyze the energy conversion needs and working principle of Special purpose electronic devices.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1													2	1
2													2	2
3													2	2
4													2	2
5													2	2

UNIT I **6 Hours**

ENERGY TRANSFER AND SIGNALS

Energy Transmission through Mechanical, Electrical and Electromagnetic means, Signal as Energy Transmission, Complexity in signal transmission (Volume of Information, Distance and Time taken), Limitations of Mechanical Energy Transmission, Electrical and Electromagnetic Signal Transmission, Need for Conversion between Electrical and Mechanical Signals.

UNIT II **8 Hours**

SIGNAL CONDITIONING USING DIODE

Need for Vacuum Tubes in the Evolution of Electronics, Overview of Vacuum Tubes, Diode and Triode, Limitations of Vacuum Tubes. Semiconductor Group in Periodic Table, Overview of Semiconductor Materials, Flow of electrical energy through PN Junction Diode, Signal Clipping, Signal Clamping and Signal Multiplication using PN Junction Diode, Limitations of PN Junction Diode.

UNIT III **6 Hours**

SIGNAL CONDITIONING USING TRANSISTOR

Need for controlling electrical signals, Principle of Bipolar Junction Transistor operation, Signal Switching and Amplification using BJT, Limitations of BJT, Principle of Field Effect Transistor operation.

UNIT IV **6 Hours**

LOGIC SYNTHESIS USING DIODE AND TRANSISTORS

Overview of Logic Gates, PN Junction and BJT as electronic switches, Digital Logic Synthesis using Diode and Transistor: Diode Logic, Resistor Transistor Logic, Diode Transistor Logic, Transistor Logic.

UNIT V **4 Hours**

DEVICES FOR SPECIAL REQUIREMENTS

Voltage Regulation using Zener Diode, Variable Capacitance using Varactor Diode, Electrical Energy to Light Energy conversion using Light Emitting Diode, Light to Energy to Electrical Energy conversion using Solar Cell.

1 **4 Hours**

EXPERIMENT 1

Design and Implement a simple device to communicate basic information between two different small distance points using wired and wireless methods.

2 **6 Hours**

EXPERIMENT 2

Design and Implement different wave shaping Circuits using PN Junction Diodes.

3 **4 Hours**

EXPERIMENT 3

Design and Implement Voltage Multiplier Circuit using PN Junction Diodes and Capacitors.

4 **4 Hours**

EXPERIMENT 4

Design and Implement t a three Stage Circuit to convert 220V 50Hz AC mains supply to 12V DC supply.

5 **4 Hours**

EXPERIMENT 5

Design and Implement a BJT Amplifier Circuit to amplify audio input signal.

6 **4 Hours**

EXPERIMENT 6

Design and Implement Basic Logic Gates using PN Junction Diodes.

7 **4 Hours**

EXPERIMENT 7

Design and Implement Basic Logic Gates using BJTs.

Total: 60 Hours

Reference(s)

1. Thomas L. Floyd ,Electronic Devices: Electron Flow Version, Ninth Edition, Prentice Hall, 2012.
2. J Millman, C. Halkias & Satyabrata JIT, Electronic Devices and Circuits, Tata McGraw-Hill, 2007.
3. L Robert Boylestead, Louis Nashelsky, Electronic Devices and Circuit Theory, Pearson Education 2006.
4. David A. Bell, Electronic Devices and Circuits, Prentice Hall of India, 2003.
5. Adel S. Sedra & Kenneth C. Smith, Micro Electronic Circuits Theory and Applications, Sixth Edition, Oxford University Press, 2013.
6. Behzad Razavi, Microelectronics, Wiley India Pvt. Ltd.; 2nd edition (2018)

22GE005 ENGINEERING DRAWING 1 0 2 2

Course Objectives

- To provide knowledge on fundamentals of engineering drawings and conic sections.
- To impart skill on orthographic projections of points and lines.
- To familiarize on projection of planes and simple solids.
- To provide knowledge on section of solids and development of surfaces of simple solids.
- To impart skill on conversion of isometric view to orthographic projection and vice versa.

Course Outcomes (COs)

1. Understand the engineering drawing concepts as per industrial standards.
2. Construct orthographic projections of points and lines.
3. Draw the projection of planes and simple solids.
4. Draw the section of solids and development of surfaces.
5. Draw the orthographic projection from isometric view and vice versa.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2							2		2		2		
2	2							2		2		2		
3	1							2		2		2		
4	1							2		2		2		
5	1							2		2		2		

UNIT I **7 Hours**

FUNDAMENTALS OF ENGINEERING DRAWING

Definition, standards, drawing tools, drawing sheets, scales, line and its types. Practices on lettering, numbering, dimension of drawings. Construction of conic sections - ellipse, parabola and hyperbola using eccentricity method.

UNIT II **9 Hours**

PROJECTION OF POINTS AND LINES

Principles of projection, projection of points in four quadrants, first angle projection of straight lines - perpendicular to one plane, parallel and inclined to both planes.

UNIT III **9 Hours**

PROJECTION OF PLANES AND SOLIDS

Projection of simple planes and projection of simple solids - parallel, perpendicular and inclined to one plane using change of position method, inclined to both the planes

UNIT IV **9 Hours**

SECTION OF SOLIDS AND DEVELOPMENT OF SURFACES

Section of Solids - simple position with cutting plane parallel, perpendicular and inclined to one plane with true shape of section. Development of surfaces - simple and truncated solids.

UNIT V **11 Hours**

ORTHOGRAPHIC PROJECTIONS AND ISOMETRIC VIEW

Orthographic projections and isometric view of components used in engineering applications.

Reference(s) **Total: 45 Hours**

1. N. D. Bhatt and V. M. Panchal, Engineering Drawing, Charotar Publishing House Pvt. Limited,2019.
2. K.V. Natarajan, A Text Book of Engineering Graphics, Dhanalakshmi Publishers, 2013.
3. K Venugopal, Engineering Drawing and Graphics, Sixth edition, New Age International, 2013.
4. Basant Agarwal, Mechanical drawing, Tata McGraw-Hill Education, 2013.
5. Engineering Drawing Practice for Schools & Colleges, Bureau of Indian Standards-Sp46, 2013.

22HS201 COMMUNICATIVE ENGLISH II 1 0 2 2

Course Objectives

- Command over the English language for day-to-day transactions.
- Improve listening and reading skills
- Increase ability to comprehend complex content
- Enhance confidence in expressing with clarity and elegance
- Enthusiastic and reflective use of the language through sufficient and focused practice
- Articulate fluently and confidently in challenging situations

Course Outcomes (COs)

1. Engage with the English language in functional contexts
2. Express in both descriptive and narrative formats
3. Understand and make effective use of the English Language in Business contexts
4. Actively read and comprehend authentic text
5. Express opinions and communicate experiences.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1									3	3		3		
2									3	3		3		
3									3	3		3		
4									3	3		3		
5									3	3		3		

UNIT I **15 Hours**

SELF-EXPRESSIONRESSION

Lesson Plan 1: Personal Goals and Values - Being a Team Player-Expressing strengths and weaknesses-Abstract nouns-Adjectives-Active Listening skills-Note making-Pronunciation and Accent Lesson Plan 2: Personal goals and values - Reading for Gist and Details-Professional ethics- Reported Speech-Conjunctions-Reading skills - phonemics, word/phrase recognition, sight words Lesson Plan 3: Personal Goals and Values-Conditional clauses- Hypothetical questions and answers- Sentence Structure-Simple Present Tense-Perfect tense

UNIT II **15 Hours**

CREATIVE EXPRESSION

Instructive and Expository Expression Creating brochures, catalogues, and manuals for products/ services, Giving directions, Process writing, Sequencing experiments, Concept explanation- Reported speech-Voice Sentence equivalence-Proofreading

UNIT III **15 Hours**

FORMAL EXPRESSION

Notices and Announcements-Writing: Creating notices and circulars for events, announcing college tours and lost and Found-Varied Vocabulary - Gender Sensitive Vocabulary, Non-discriminatory Vocabulary, Concise Vocabulary-Paragraph writing - Effective titles, topics and supporting sentences, calling in registrations and

queries. Effective communication- Understanding purpose, reach and target audience, achieving complete communication Punctuation - Capitalization, Numeration, Use of proper nouns and Articles-Spelling-Reading: Analyzing and interpreting notices and Circulars-Understanding the gist of short real-world notices, and messages. Culling out keywords Information words vs Supporting words-Interpreting Abbreviations, Acronyms and Short-forms-Listening: Analyzing and interpreting announcements Decoding - Screening for salient points-Note making-Raising queries for clarification-Speaking: Announcements-Giving complete information-Pronunciation and Enunciation Pace, Intonation, and Pitch-Conducting Events-Speaking: Master of ceremonies, Short speeches - welcome speech, the vote of thanks/ valedictory speech, award-acceptance speech Writing: Invitations, Preparation of script/draft after interviewing someone. Adjectives-Pronunciation/ Punctuation Precision and Concision-Politeness markers

Total: 45 Hours

Reference(s)

1. Sasikumar, V, et.al. A Course in Listening & Speaking FoundationBooks, 2005.
2. Murphy, Raymond. English Grammar in Use: A Self-Study Reference and Practice Book for Intermediate Students: with Answers. Cambridge: Cambridge University Press, 1985.
3. Prasad, Hari Mohan. A Handbook of Spotting Errors. Mcgraw Hill Education, 2010.
4. Reynolds, John. Cambridge First Language English. 2018th ed., Hodder Education, 2018.
5. Wiggins, Grant P., and Jay McTighe. Understanding by Design. Association for Supervision and Curriculum Development, 2008.

22HSH01 HINDI **1 0 2 2**

Course Objective(s)

- To help students acquire the basics of Hindi
- To teach them how to converse in Hindi on simple day- to -day situations
- To help students understand a simple technical text in Hindi

Course Outcomes (COs)

1. Construct simple sentences and use vocabulary required for day- to -day conversation.
2. Distinguish and understand the basic sounds of Hindi language.
3. Apply appropriate grammar to write and speak in Hindi language
4. Comprehend the conversation and give correct meaning
5. Take up Hindi examinations conducted by Dakshin Bharat Hindi Prachar Sabha

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1									3	3				
2									3	3				
3									3	3				
4									3	3				
5									3	3				

UNIT I **9 Hours**

VOWELS AND CONSONANTS

Hindi Alphabet: Introduction (Self introduction) - Vowels - Consonants - Plosives - Fricatives - Nasal sounds - Vowel Signs - Chandra Bindu & Visarg -Table of Alphabet -Vocabulary.

UNIT II **9 Hours**

NOUNS

Nouns: Genders -Masculine & Feminine -Reading Exercises

UNIT III **9 Hours**

PRONOUNS AND TENSES

Pronouns and Tenses - Categories of Pronouns - Personal Pronouns - Second person (you & honorific) - Definite & Indefinite pronouns - Relative pronouns - Present tense - Past tense - Future tense - Assertive & Negative Sentences - Interrogative Sentences.

UNIT IV **9 Hours**

CLASSIFIED VOCABULARY

Classified Vocabulary: Parts of body -Relatives Spices Eatables -Fruit & Vegetables -Clothes - Directions -Seasons Professions.

UNIT V **9 Hours**

CONVERSATIONS

Speaking - Telling the times -Saying the Numbers from 1 to 50 Speaking practice for various occasions.

Total: 45 Hours

Reference(s)

1. B.R. Kishore, Self Hindi Teacher for Non-Hindi Speaking People, Vee Kumar Publications (P) Ltd., New Delhi, 2009.
2. Hindi Prachar Vahini - 1
3. Videos, Stories, Rhymes and Songs.

22HSG01 GERMAN **1 0 2 2**

Course Objective(s)

- To help students appear for the A1 level Examination
- To teach them how to converse fluently in German in day-to-day scenarios

Course Outcomes (COs)

1. Listen and identify individual sounds of German
2. Use basic sounds and words while speaking
3. Read and understand short passages on familiar topics
4. Use basic sentence structures while writing
5. Understand and use basic grammar and appropriate vocabulary in completing language tasks

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1									3	3				
2									3	3				
3									3	3				
4									3	3				
5									3	3				

UNIT I **9 Hours**

INTRODUCTION

Introduction to the German language-Alphabets-Numbers Greetings -Days and Seasons-Working with Dictionary.

UNIT II **9 Hours**

LANGUAGE AND ITS COMMON USE

Nouns -articles-Speaking about oneself-Listening to CD supplied with books-paying special attention to pronunciation

UNIT III **9 Hours**

TECHNICAL DEUTSCHE

Regular &Irregular verbs -Personal pronouns-family-Introduction to types of sentences

UNIT IV **9 Hours**

INTERROGATION

Question words -Types of Questions -Nominative case-Verb Conjugation -country -nationalities

UNIT V **9 Hours**

IMPLEMENTATION

Verbs to be & to have -conjugation -Hobbies -Framing basic Questions and answers

Total: 45 Hours

Reference(s)

1. Kursbuch and Arbeitsbuch, NETZWERK A1 DEUTSCH ALS FREMDSPRACHE, Goyal Publishers & Distributers Pvt. Ltd., New Delhi, 2015.
2. Langenscheidt Eurodictionary, German English / English German, Goyal Publishers & Distributers Pvt. Ltd., New Delhi, 2009.
3. Grundkurs, DEUTSCH Lehrbuch Hueber Munichen, 2007.

22HSJ01 JAPANESE **1 0 2 2**

Course Objective(s)

- To train students for N5 Level Examination
- To teach them use basic Japanese sentences in day-to-day conversation
- To make students familiar with the Japanese cultural facets and social etiquette

Course Outcomes (COs)

1. Recognize and write Japanese alphabet
2. Speak using basic sounds of the Japanese language
3. Apply appropriate vocabulary needed for simple conversation in Japanese language
4. Apply appropriate grammar to write and speak in Japanese language
5. Comprehend the conversation and give correct meaning

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1									3	3				
2									3	3				
3									3	3				
4									3	3				
5									3	3				

UNIT I **9 Hours**

SELF INTRODUCTION / DEMONSTRATIVES / NOUN MODIFIERS

Introduction to Japanese Japanese script -Pronunciation of Japanese(Hiragana (Katakana) Long vowels -Pronunciation of in,tsu,ga -Letters combined with ya,yu,yo -Daily Greetings and Expressions-Numerals. Speaking: Self Introduction-Listening: Listening to Greetings, Listening to specific information:Numbers, Time

UNIT II **9 Hours**

TIME EXPRESSION / VERBS - PAST

Introduction to time-Introduction of verbs -Listening to specific information

UNIT III **9 Hours**

ADJECTIVES

Word Sentence-Introduction to Adjectives-Technical Japanese Vocabulary -Pair Activity Day to day -situational conversation-Listening to Japanese Alphabet Pronunciation-Simple Conversation

UNIT IV **9 Hours**

CONJUGATION OF II ADJECTIVE

Past tense of Noun sentences and Na adjective sentences-Past tense of ii adjective sentences houga adjective desu-Technical Japanese Vocabulary-Individual Activity Listening to conversation with related particles

UNIT V **9 Hours**

CONJUGATION OF VERBS - TE FORM / TA FORM / NAI FORM / PLAIN FORM

N gahoshidesu-V masu form tai desu-Verb te form-Technical Japanese Vocabulary Listening to different Counters, simple conversations with verbs and adjectives

Total: 45 Hours

Reference(s)

1. Minna no Nihongo Japanese for Everyone Elementary Main Textbook1-1, Goyal Publishers and Distributors Pvt. Ltd., Delhi, 2007.
2. Minna no Nihongo Japanese for Everyone Elementary Main Textbook 1-2 Goyal Publishers and Distributors Pvt. Ltd., Delhi, 2007.

22HSF01 FRENCH **1 0 2 2**

Course Objectives

- To prepare the students for DELF A1 Examination
- To teach them to converse fluently in French in day-to-day scenarios

Course Outcomes (COs)

1. Help students acquire familiarity in the French alphabet & basic vocabulary
2. Listen and identify individual sounds of French
3. Use basic sounds and words while speaking
4. Read and understand short passages on familiar topics
5. Understand and use basic grammar and appropriate vocabulary in completing language tasks

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1									3	3				
2									3	3				
3									3	3				
4									3	3				
5									3	3				

UNIT I **9 Hours**

ENTRER EN CONTACT

La langue franÃƒÂ§aise, alphabets, les numÃƒÂ©ros, les jours, les mois. Grammaire Les verbes s appeler, etre, avoir, les articles definis, indefinis Communication Saluer, s informer sur quelqu un, demander de se presenter Lexique L alphabet, les nationalites, l age, les pays, les couleurs, les jours de la semaine, les mois de l annee, les professions

UNIT II **9 Hours**

PARTAGER SON LIEU DE VIE

Les francais et leur habitat, des habitations insolites Grammaire Verbes Conjugaison Present (Avoir / Etre / ER, IR, RE Regulier et Irregulier) Adjectifs les propositions de lieu Communication Chercher un logement, decrire son voisin, s informer sur un logement Lexique L habitat, les pieces, l equipement, la description physique

UNIT III **9 Hours**

VIVRE AU QUOTIDIEN LES LOISIRS DES FRANCAIS, LES GOUTS DES AUTRES, LES ACTIVITES QUOTIDIENNES

Grammaire Articles contractes, verbes vouloir, pouvoir, devoir, adjectifs interrogatifs, future proche Communication Exprimer ses gouts, parler de ses loisirs, justifier un choix, exprimer une envie Lexique le temps libre et les loisirs, les saisons, les activites quotidiennes, le temps (le matin, le soir, la nuit)

UNIT IV **9 Hours**

COMPRENDRE SON ENVIRONNEMENT SOUVRIR A LA CULTURE

Grammaire Verbes Finir, Sortir, les adjectifs demonstratifs, le passe compose, l imparfait Communication Propose a quelqu un de faire quelque chose, raconter une sortie au passe, parler d un film Lexique Les sorties, la famille, l art, les vetements et les accessoires

UNIT V **9 Hours**

GOUTER A LA CAMPAGNE

Grammaire La forme negative, les verbes acheter, manger, payer, articles partitifs, le pronom en de quantite

Communication Accepter et refuser une invitation, donner des instructions, commander au restaurant Lexique Les services et les commerces, les aliments, les ustensiles, l argent

Total: 45 Hours

Reference(s)

1. Grammaire Progressive du Francais, CLE International, 2010
2. Saison1, Marie Noelle Cocton et al, Didier, 2014.
3. Preparation a l examen du DELF A1 Hachette
4. Reussir le DELF A1 Bruno Girardeau
5. Website: Francais Linguaphone Linguaphone Institute Ltd., London, 2000.
6. Francais Harrisonburg : The Rosetta Stone : Fairfield Language Technologies, 2001

22HS003 HERITAGE OF TAMILS 1 0 0 1

Course Objectives

- Describe the linguistic diversity in India, highlighting Dravidian languages and their features
- Summarize the evolution of art, highlighting key transitions from rock art to modern sculptures
- Examine the role of sports and games in promoting cultural values and community bonding
- Discuss the education and literacy systems during the Sangam Age and their impact.
- Outline the importance of inscriptions, manuscripts, and the print history of Tamil books in preserving knowledge and culture

Course Outcomes (COs)

1. Understand the concept of language families in India, with a focus on Dravidian languages.
2. Trace the evolution of art from ancient rock art to modern sculptures in Tamil heritage.
3. Identify and differentiate various forms of folk and martial arts in Tamil heritage.
4. Understand the concepts of Flora and Fauna in Tamil culture and literature.
5. Evaluate the contributions of Tamils to the Indian Freedom Struggle.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1									2	3				
2									2	3				
3									2	3				
4									2	3				
5									2	3				

UNIT I **3 Hours**

LANGUAGE AND LITERATURE

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

UNIT II **3 Hours**

HERITAGE - ROCK ART PAINTINGS TO MODERN ART- SCULPTURE

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

UNIT III **3 Hours**

FOLK AND MARTIAL ARTS

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

UNIT IV **3 Hours**

THINAI CONCEPT OF TAMILS

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

UNIT V **3 Hours**

CONTRIBUTION OF TAMILS TO INDIAN NATIONAL MOVEMENT AND INDIAN CULTURE

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

Total: 15 Hours

Reference(s)

1. Dr. K. K. Pillay, Social Life of Tamils, A joint publication of TNTB & ESC and RMRL.
2. Dr. S. Singaravelu, Social Life of the Tamils - The Classical Period, International Institute of Tamil Studies.
3. Dr. S. V. Subatamanian, Dr. K. D. Thirunavukkarasu, Historical Heritage of the Tamils, International Institute of Tamil Studies.
4. Dr. M. Valarmathi, The Contributions of the Tamils to Indian Culture, International Institute of Tamil Studies.
5. Keeladi, Sangam City Civilization on the banks of river Vaigai, Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu
6. Dr. K. K. Pillay, Studies in the History of India with Special Reference to Tamil Nadu.
7. Porunai Civilization, Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu
8. R.Balakrishnan, Journey of Civilization Indus to Vaigai, RMRL.

22HS003 - தமிழர் மரபு **1 0 0 1**

பாடத்திட்டத்தின நோக்கம்

1. இந்திய தொழிற்கூடுமபத்துள தொன்மை தொழிகள தனித்து இயங்கும தனமமமய அதன சிறபபுகள வழி அறிதல்.
2. தத்தனறுதத்தொடடு தமழர, கமலயில அமடநத வளரசசிமய இயமபுதல்.
3. சங்ககால தமழரின கறறல தொறத்மத இலகக்கியங்கள வழி ஆரொயதல்.

கறறலின வளைவு

1. இந்திய தொழிற்கூடுமபத்துள தொன்மை தமிழிகள தனித்து இயங்கும தனமமமய அதன சிறபபுகள வழி அறிதல்.
2. தத்தனறுதத்தொடடு தமழர, கமலயில அமடநத வளரசசிமய இயமபுதல்.
3. சங்ககால தமழரின கறறல தொறத்மத இலகக்கியங்கள வழி ஆரொயதல்.
4. தமழ தொழியின சிறபபுகமள அதன பமடபபிலக்கியங்கள றலம அறிந்து தெளிளுதல்.
5. கறகாலம தத்தொடங்கி, இகாலம வமர சிறபகமல அமடநத வளரசசிமய கணடுதகாளளல .
6. தமழர தம வொழவல எங்கனம இயறமகமய வணங்கி பபொறறினர எனபமத திமண பகொடப்பொட்டின வழி ததளிதல்.
7. இந்திய வடுதமல பபொரில தமழர ஆறறிய பங்கிமன ததரிந்து தெளிளுதல்.

அலகு I மொழி மற்றும் இலக்கியம்: **3**

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

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

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

அலகு III நாட்டுப்புறக் கலைகள் மற்றும் வீர விளையாட்டுகள்: 3

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

அலகு IV தமிழர்களின் திணைக் கோட்பாடுகள்: 3

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

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

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

TOTAL : 15 PERIODS

TEXT-CUM-REFERENCE BOOKS

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

22EE301 COMPLEX INTEGRATION, TRANSFORMS AND PARTIAL DIFFERENTIAL EQUATIONS

3 1 0 4

Course Objectives

- Explain the concepts of analytic functions in complex domain to predict the nature of different engineering systems.
- Understand the concepts of Fourier series, Transforms and Boundary Conditions, which will enable them to model and analyze the physical phenomena.
- Implement the Fourier analysis, an elegant method in the study of heat flow, fluid mechanics and electromagnetic fields.
- Develop enough confidence to identify and model mathematical patterns in real world and offer appropriate solutions, using the skills learned in their interactive and supporting environment

Programme Outcomes (POs)

a. PO1: Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineeringspecialization to the solution of complex engineering problems.
b. PO2:I Problem Analysis: dentify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

Course Outcomes (COs)

1. Apply the concept of analytic function to estimate the integral in complex plane.
2. Identify the periodicity of a function and formulate the same as a combination of sine and cosine using Fourier series and formulate a function in frequency domain whenever the function is defined in time domain.
3. Formulate a function in frequency domain whenever the function is defined in time domain using Fourier transforms.
4. Apply the concepts of Laplace transforms to convert functions in time domain to S- domain.
5. Apply the concept of partial differential equations to solve the problems in electrical field.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	1	2											2	
2	1	2											2	
3	1	2											2	
4	1	2											2	
5	1	2											2	

UNIT I **9 Hours**

COMPLEX INTEGRATION

Cauchy's Fundamental Theorem - Cauchy's Integral Formula - Taylor's and Laurent's series- Classification of Singularities - Cauchy's Residue Theorem.

UNIT II **9 Hour**

FOURIER SERIES

Introduction-Periodic Functions- Dirichlet's Conditions - General Fourier Series - Odd and Even Functions - - Parseval's Identity-Root Mean Square Value- Harmonic Analysis

UNIT III **9 Hours**

FOURIER TRANSFORM

Fourier Integral Theorem- Fourier Transform and Inverse Fourier Transform- Sine and Cosine Transforms - Properties - Transforms of Simple Functions - Convolution Theorem - Parseval's Identity

UNIT IV **9 Hours**

LAPLACE TRANSFORM

Laplace Transform: Existence of Laplace transform- Properties of Laplace Transform-Laplace Transform of Periodic Function. Inverse Laplace Transform: Properties of Inverse Laplace Transform- Partial Fraction Method- Convolution- Application of Laplace Transform to Ordinary Differential Equations with Constant Coefficients.

UNIT V **9 Hours**

APPLICATIONS OF PARTIAL DIFFERENTIAL EQUATIONS

Classification of Partial Differential Equations of Second Order - Solution of: One Dimensional Wave Equation, One Dimensional Heat Equation, Two Dimensional Heat Equation.

Total: 60 Hours

Reference(s)

1. Erwin Kreyszig, Advanced Engineering Mathematics, Tenth Edition, Wiley India Private Limited, New Delhi, 2016.
2. Peter V O Neil, Advanced Engineering Mathematics, 7th Edition, TBH Publishers, 2013.
3. James Glyn, Advanced Modern Engineering Mathematics, Pearson, 3rd edition 2014.
4. Michael D Greenberg., Advanced Engineering Mathematics, Pearson Education, 2nd Edition 2002.
5. B. S. Grewal, Higher Engineering Mathematics, Forty third Edition, Khanna Publications, New Delhi 2015.

22EE302 CIRCUIT ANALYSIS 3 1 0 4

Course Objectives

- To apply basic laws in Circuits and to calculate the voltages and current in a circuit using basic theorems.
- To apply the concept of transients and resonance in series and parallel circuit.
- To develop two port networks and analysis different types of two port networks.

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

e. PO5.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.

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Apply Voltage-Current laws and transformation techniques to solve linear electric circuits and analyse the phase relationships of circuits with RLC components.
2. Determine the electrical parameters of the circuits by using network theorems.
3. Analyse the steady state and transient response of RLC circuit using Laplace transform.
4. Analyse the frequency response of an electric circuit.
5. Determine driving point and transfer function of two port network and classify different two port network.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2			1								2	2
2	3	2											2	2
3	3	2											2	2
4	2	3											2	2
5	2	3											2	2

UNIT I **10 Hours**

CIRCUIT LAWS AND ANALYSIS TECHNIQUES

Basic electrical components, Voltage - current laws, Divider theorem, Short and Open Circuits, Phase relationship for R, L and C, Impedance and Admittance for R, L and C, Mesh and Nodal Analysis for AC and DC circuits, Source transformation techniques, Star delta transformation techniques.

UNIT II **9 Hours**

NETWORK THEOREMS FOR DC AND AC CIRCUITS

Superposition theorem – Thevenin's theorem – Norton's theorem - Maximum power transfer theorem -Reciprocity theorem.

UNIT III **8 Hours**

STEADY STATE AND TRANSIENT ANALYSIS OF AC AND DC CIRCUITS

Steady state and Transient analysis of RL, RC, RLC circuits using Laplace Transform for both AC and DC input.

UNIT IV **9 Hours**

RESONANCE AND MAGNETICALLY COUPLED CIRCUITS

Resonance: Natural frequency and Damping Ratio - Series Resonance - Parallel Resonance - Quality Factor. Coupled Circuits: Self-inductance- Mutual inductance - Dot conversion - Ideal Transformer.

UNIT V **9 Hours**

LINEAR TWO PORT NETWORK PARAMETERS

Driving point and transfer function of two port network, Z, Y, T, inverse T, Hybrid, Inverse Hybrid Parameters and its conversion.

FOR FURTHER READING

Simulation of Circuits and Evaluation of its parameters: Basic Concepts and Definitions, Analysis of Simple Circuits, Nodal and Mesh Equations - Circuit Theorems, Natural Response, Forced and Total Response in RL and RC Circuits.

Total: 60 Hours

Reference(s)

1. William Hayt, J V Jack, E Kemmerly and Steven M Durbin, Engineering Circuits Analysis, Tata McGraw-Hill, 2013.
2. Joseph Edminister and Mahmood Nahri, Theory and Problems of Electric Circuits Tata McGraw-Hill, 2008.
3. A Sudhakar, S Shyammohan and Palli, Circuits and Network (Analysis and synthesis) Tata McGraw-Hill, 2010.
4. L Robert Boylested, Experiments in Circuit Analysis to Accompany Introductory Circuit Analysis, PHI, 2002.
5. M. Russell, Mersereau and Joel R. Jackson, Circuit Analysis- A System Approach, Pearson Education, 2009.
6. Steven T. Karris, Circuit Analysis I with MATLAB Applications, Orchard Publications, 2004.

22EE303 ELECTRICAL MACHINES I 3 1 0 4

Course Objectives

- To understand the production of torque and EMF.
- To understand the construction, operation and characteristics of various types of DC machines.
- To understand the performance of single phase transformer
- To understand the performance of three phase transformers
- To estimate the construction, operation, starting and speed control of induction motor

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

e. PO5.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.

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Analyze the various types and characteristics of DC Generator and DC motor.
2. Design an equivalent circuit and analyze the performance of the single phase transformers.
3. Analyze the three phase transformer connections for generation and distribution applications.
4. Analyze the characteristics, equivalent circuit of single phase and three phase induction motor.
5. Apply suitable starting and speed control methods for three phase induction motors.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2			2								2	
2	2	2			2								2	
3	2	2			2								2	2
4	3	2			2								3	2
5	2	2			2								3	2

UNIT I **10 Hours**

DC MACHINES

Generator and Motor- Construction - Principle of operation - Types - Characteristics - Armature reaction and commutation - Starting and Speed control -Various Testing –Applications.

UNIT II **9 Hours**

SINGLE PHASE TRANSFORMERS

Construction - Principle of operation - Types - Equivalent circuit -Voltage regulation and efficiency -Auto transformer- Testing of transformers -Polarity, open circuit, short circuit and Sumpner's test.

UNIT III **8 Hours**

THREE PHASE TRANSFORMER

Type of connections, Relation between line and phase voltages and currents, Scott connection of transformers for phase conversion, Parallel operation of transformer, on-load and off-load tap changing transformer.

UNIT IV **10 Hours**

INDUCTION MOTOR

Construction of three phase induction motor- Types of rotor - Operation - torque equation - Torque - slip characteristics - Equivalent circuit model - Double Revolving Field Theory - Methods of Starting: Capacitor start - Capacitor start capacitor run single phase induction motor.

UNIT V **8 Hours**

STARTING AND SPEED CONTROL OF THREE PHASE INDUCTION MOTOR

Need for starters - Methods of starting - Fully automated starters: DOL, Autotransformer, star delta starter - rotor resistance starter - Methods of Speed Control - V/f Control and Pole Changing Techniques.

Total: 60 Hours

Reference(s)

1. M.G.Say, Performance and Design of Alternating Current Machines, 3rd Edition, CBS Publisher, 2017.
2. D. P. Kothari and I. J. Nagrath, Electric Machines, Tata McGraw Hill Publishing Company Ltd, Fourth Edition 2018.
3. Stephen J.Chapman, Electric Machinery Fundamentals, Tata McGraw Hill, New Delhi, 2018.
4. E. Fitzgerald, Charles Kingsley, Stephen.D.Umans, Electric Machinery, Tata McGraw Hill publishing Company Ltd, New Delhi ,2015.
5. P. S. Bhimbhra, Electrical Machinery, Khanna Publishers, Seventh Edition 2018.

22EE304 ANALOG CIRCUITS AND SYSTEMS 3 0 2 4

Course Objectives

- To understand the fundamentals of BJT and Feedback amplifiers.
- To understand the characteristics, linear and Non-linear applications of Op-amp.
- To analyze the different types of opamp based Oscillators.
- To understand the operation of A/D and D/A converters using Op-amp and other special ICs.
- To familiarize the students with the PLDs and VHDL.

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems
b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.
n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Analyze the biasing techniques and Amplifiers based on BJT.
2. Analyze the characteristics and develop simple circuits for various applications of the Op-amp.
3. Develop simple Op-amp based waveform generators.
4. Construct A/D and D/A converters for signal processing applications and analyse the Special ICs.
5. Apply various types of PLDs used in electronics appliances.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	3											1	
2	3	3	3										3	2
3	3	3	3										3	2
4	2	2	2										3	2
5	2	3	3										3	3

UNIT I **9 Hours**

TRANSISTOR BIASING & FEEDBACK AMPLIFIERS

Transistor Biasing- Bias Stability, Bias Compensation, Cascade and Cascade Amplifier, Difference Amplifier Feedback amplifiers - Current Series, Voltage Shunt, Current shunt and Voltage Series. Power Amplifiers: Class A, Class B, Class C and Class AB Power Amplifiers, Distortion in Power Amplifiers.

UNIT II **9 Hours**

OP-AMP CHARACTERISTICS & APPLICATIONS

Ideal Op Amp- Operational Amplifier Internal Circuit- DC Characteristics, AC Characteristics – Slew Rate - Inverting and Non inverting Amplifiers- Voltage Follower- Summing Amplifier - Subtractor - Differentiator- Integrator- Instrumentation amplifier, 1st Order LPF, HPF and all-pass filters.

UNIT III **9 Hours**

WAVEFORM GENERATORS

Barkhausen criterion - Oscillators using BJT: LC - Hartley, Colpitts and Crystal Oscillators - Principles of Op- Amp based Sine wave Oscillator - RC Phase Shift, Wien Bridge Oscillator – Multivibrators (Op-Amp & 555) - Astable, Monostable and Bistable.

UNIT IV **9 Hours**

COMPARATORS, DATA CONVERTERS AND SPECIAL FUNCTION ICS

Open Loop Op-Amp Configuration – Comparator- Schmitt trigger - Sample and Hold circuits – Flash ADC - Dual Slope ADC - Binary Weighted Resistor DAC - R-2R Ladder DAC – VCO - Voltage regulator: Fixed andAdjustable.

UNIT V **9 Hours**

PROGRAMMABLE LOGIC DEVICES AND LOGIC FAMILIES

Programmable Logic Devices: PLA, PAL, Logic families: TTL, ECL, IIL, CMOS, Introduction to VHDL programming - Behavioural, Dataflow, and structural modeling - simple VHDL codes.

1 **10 Hours**

EXPERIMENT 1

Design and build a simple audio amplifier using Operational Amplifier /Transistor.

2 **10 Hours**

EXPERIMENT 2

Design and implement an inverter to drive an household application (Say microwave)

3 **10 Hours**

EXPERIMENT 3

Designing Calculator using VHDL Specifications(Addition, Subtraction)

Total: 75 Hours

Reference(s)

1. David A.Bell, 'Op-amp & Linear ICs', Oxford, 2013.
2. Ramakant A.Gayakward, 'Op-amps and Linear Integrated Circuits', IV edition, Pearson Education, 2015.
3. Adel. S. Sedra , Kenneth C. Smith, Microelectronic Circuits Theory an Applications ,7th Edition, Oxford University, 2017.
4. Jacob Millman, C. Halkias and Satyabrata Jit Electronic Devices and Circuits, 4TH Edition, Tata McGraw- Hill, 2015.
5. Vaibbhav Taraate, “PLD Based Design with VHDL: RTL Design, Synthesis and Implementation”, first Edition, Springer 2017.

22EE305 DATA STRUCTURES AND ALGORITHMS 2 0 2 3

Course Objectives

- To understand the concept of computer programming.
- To develop problem solving skills and troubleshooting techniques in electronics.
- To develop critical reasoning and problem solving abilities including the use of simulation software for designing and troubleshooting.

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

d. PO4.Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

e. PO5.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.

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Develop abstract data type models and design recursive algorithms.
2. Develop applications by using the concept of Stack, Queues and List.
3. Analyze various sorting and searching algorithms.
4. Apply the Binary Search tree, AVL search tree and Heap tree in writing C++ programs.
5. Apply minimum spanning tree and shortest path algorithms for real time problems.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	1	1	3	3								2	1
2	2			2	2								2	1
3	1	2		3	3								1	2
4	1			3	2								2	2
5	1	3	1	3	3								2	2

UNIT I **6 Hours**

INTRODUCTION

Pseudo code-Abstract Data types-Model for an ADT-ADT Implementations-Algorithm Efficiency- Designing Recursive Algorithms-Recursive Examples.

UNIT II **7 Hours**

LINEAR LIST: STACKS, QUEUES AND LISTS

Arrays : Basic Stack Operation-Stack ADT - Applications of Stack : Queues Operations- Queue ADT -Queue Applications-Linked List-Operations- Basic concepts of Circular and Doubly Linked List.

UNIT III **6 Hours**

SORTING AND SEARCHING

Sorting: Insertion Sort-Selection Sort-Bubble Sort - Quick sort-Heap sort-shell sort-External Sorts-Merge sort-Searching: Sequential search- Binary Search - Hashing-General Idea - Hash Function - Separate Chaining - Open Addressing - Linear Probing.

UNIT IV **5 Hours**

NON LINEAR LIST: TREES

Basic Tree concepts - Binary Trees-Tree Traversals -Expression Trees-Binary Search Trees - AVL Search Trees-Heap concepts-Implementation-Heap Applications: Priority Queue.

UNIT V **6 Hours**

GRAPHS

Definitions - Graph Representations - Adjacency matrix- Adjacency List-Traverse Graph: Depth first Traversal-Breadth first Traversal-Shortest Path Algorithms: Dijkstra"s Algorithm. Minimum Spanning Tree: Prim"s Algorithm- Kruskal"s Algorithm.

1 **3 Hours**

EXPERIMENT 1

Program to perform various operations such as creation, insertion, deletion, search of node and display on singly linked list.

2 **2 Hours**

EXPERIMENT 2

Array Implementation of stack and queue with pre and post conditions.

3 **3 Hours**

EXPERIMENT 3

Linked List Implementation of stack and queue.

4 **3 Hours**

EXPERIMENT 4

Program to sort the elements in ascending order using selection sort and bubble sort.

5 **2 Hours**

EXPERIMENT 5

Program to sort the elements in ascending order using shell sort and quick sort.

6 **2 Hours**

EXPERIMENT 6

Implementation of descending order to sort the elements using Heap sort.

7 **3 Hours**

EXPERIMENT 7

Implementation of Merge Sort.

8 **2 Hours**

EXPERIMENT 8

Develop a program to perform linear and binary search.

9 **2 Hours**

EXPERIMENT 9

Implementation of binary tree traversals.

10 **2 Hours**

EXPERIMENT 10

Write a program to perform infix into postfix expression, prefix to postfix expression.

11 **2 Hours**

EXPERIMENT 11

Implementation of breadth first search and depth first search techniques.

12 **2 Hours**

EXPERIMENT 12

Design a postfix calculator (So 1 3 2 4 * - should calculate 1 - (3 * (2 4)).) using stack.

13 **2 Hours**

EXPERIMENT 13

Design a Palindrome Checker using Dequeue.

Total: 60 Hours

Reference(s)

1. F.RichardGilberg, A.Behrouz. Forouzan, Data Structures, A Pseudocode Approach with C, Thomson,2007.
2. M. A. Weiss, Data Structures and Algorithm Analysis in C, Pearson Education, 2009.
3. Y.Langsam, M. J.Augenstein and A. M.Tenenbaum, Data Structures using C, Pearson Education,2004.
4. A. M.AhoHopcroft and J.D. Ullman, Data Structures and Algorithms, Pearson education, 2000.

22HS004 HUMAN VALUES AND ETHICS 2 0 0 2

Course Objectives

- Understand the concept of good values and comprehend the importance of value-based living.
- Recognize the culture of peace through education.
- Identify and apply the practices for value development and clarification.

Course Outcomes (COs)

1. Understand the importance of human values and ethics in life.
2. Execute the importance of harmonious living in a diverse society.
3. Analyze the sensitivity to the crying needs of society such as ungodliness, corruption, poverty, and suffering, and play a vital role in eradicating them.
4. Plan intellectually mature, morally upright, ethically correct, and spiritually inspired decisions.
5. Execute a correct balance between professional excellence and social commitment.

UNIT I **6 Hours**

COURSE INTRODUCTION - NEED, BASIC GUIDELINES AND ANALYSIS

1.Importance of Human Values & Ethics in 21st Century
2.Understanding the theory of basic human values and ethics
Openness to change- Self-enhancement- Conservation- Self-transcendence
3. Schwartz Value Survey: Self-Assessment

UNIT II **6 Hours**

EMBRACING THE COMMON ETIQUETTE

Altruism- Integrity-Freedom-Justice-Honesty-Truthfulness-Responsibility-Compassion

UNIT III **6 Hours**

CONTINUOUS HAPPINESS AND PROSPERITY

An overview on basic Human Aspirations- Understanding and living in harmony at various levels of life- Embracing self-love and wellness-Understanding harmony in the family and society

UNIT IV **6 Hours**

UNIVERSAL HUMAN VALUES AND PROFESSIONAL ETHICS

Reflection on growing global multifold problems: poverty, pollution, hunger, disease, unemployment, caste system, child labour, gender equality, politicsandviolence. Understanding the challenges in cultural, personal, social, political, and economic environment

UNIT V **6 Hours**

UNDERSTANDING HARMONY IN THE NATURE AND EXISTENCE - WHOLE EXISTENCE AS CO-EXISTENCE

Understanding the harmony in the Nature- Holistic perception of harmony at all levels of existence- Practice Exercises and Case Studies

Total: 30 Hours

Reference(s)

1. Martin, G. The Little Book of Ethics: A Human Values Approach. Australia: G.P. Martin. 2011.
2. Gupta, N. L. Human Values For The 21St Century. India: Anmol Publications Pvt. Limited. 2002.
3. Mishra, A. Happiness Is All We Want. India: Bloomsbury Publishing.2017.
4. Universal Human Values. (n.p.): Booksclinic Publishing. 2023.
5. A Textbook on Professional Ethics And Human Values. India: New Age International (P) Limited.2007.

22HS005 SOFT SKILLS AND EFFECTIVE COMMUNICATION

0 0 2 1

Course Objectives

- Communicate proficiently in formal discussions at the workplace.
- Describe experiences and events, and briefly give reasons and explanations for opinions and plans.
- Interact with a degree of fluency and spontaneity that results in efficacious communication
- Convey agreement and disagreement in a polite but firm manner
- Communicate with coherence and imagination in both written and spoken formats

Course Outcomes (COs)

1. Enhance confidence in expressing thoughts in grammatically proper language and etiquette in waiting for the opportunity to provide input.
2. Effectively communicate in English on formal occasions and proficiency in the use of link words and other discourse markers
3. Provide constructive feedback and file logical complaints.
4. Analyse the understanding of oral and written communication in real-world situations.
5. Apply the improved spelling and punctuation in writing and heightened understanding of tone, pitch and stress in oral formats.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1									2	3				
2									2	3				
3									2	3				
4									2	3				
5									2	3				

UNIT – I - SELF-EXPRESSION **10 Hours**

Group discussion/ Peer discussion - Communicating decisions and opinions - Tone, Pitch, Stress - Agreeing, Disagreeing, Suggesting, Speculating - Comparing and Contrasting - Comparatives and Superlatives - Discourse markers – Interjections - Decision making - Synthesis - Higher order thinking Group discussion/Peer discussion - Effective Communication Types of communication - Written vs Spoken - Contractions Intonation Stress Active voice - Question tags - Confidence and body language Guided writing- Outlining Main Points - Group discussion/Peer discussion - Avoiding common errors Reduction of MTI - Common errors - Barriers to communication Accent

UNIT – II - CREATIVE EXPRESSION **10 Hours**

JAM, Debate, Review writing, Social media posts Synonyms - Antonyms Cloze test Phrasal verbs Spotting errors Collocation - Commonly mispronounced

UNIT – III - FORMAL EXPRESSION **10 Hours**

Writing: Giving written feedback, Review writing, and Letter of complaint. Speaking: Giving constructive feedback and offering suggestions, asking for inputs, commenting politely on appropriate phrases - Giving written feedback, Review writing, and Letter of complaint. Critical reasoning - Modal verbs - Polite ways to express negatives

Total: 30 Hours

Reference(s)

1. Word Power Made Easy by Norman Lewis, W. R. Goyal Pub. & Distributors, 2009.
2. Sasikumar, V, et al., A Course in Listening & Speaking Foundation Books, 2005.
3. Murphy, Raymond. English Grammar in Use: A Self-Study Reference and Practice Book for Intermediate Students: with Answers. Cambridge: Cambridge University Press, 1985.
4. Prasad, Hari Mohan. A Handbook of Spotting Errors, Mcgraw Hill Education, 2010.
5. Personality Development & Soft Skills, BarunK.Mitra, Oxford University Press, 2012
6. Business English by Ken Taylor, Orient Blackswan, 2011

22HS006 TAMILS AND TECHNOLOGY **1 0 0 1**

Course Objectives

1. Analyse graffiti on potteries as a form of historical and cultural documentation during the Sangam Age.
2. Investigate the building materials and the historical context of Hero stones during the Sangam Age by Analysing the details of stage constructions in Silappathikaram and their cultural significance.
3. Examine ancient knowledge of oceans and its impact on Tamil society.

Course Outcomes (COs)

1. Understand the significance of the weaving industry during the Sangam Age and its cultural importance.
2. Understand the significance of dams, tanks, ponds, and sluices in the agricultural and irrigation practices of the Chola Period.
3. Explore the architectural designs and structural construction methods used in household materials during the Sangam Age.
4. Explore the art of shipbuilding in ancient Tamil culture and its role in maritime trade and transportation.
5. Trace the development of scientific terminology and vocabulary in Tamil language.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1									2	3				
2									2	3				
3									2	3				
4									2	3				
5									2	3				

UNIT I **3 Hours**

WEAVING AND CERAMIC TECHNOLOGY

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

UNIT II **3 Hours**

DESIGN AND CONSTRUCTION TECHNOLOGY

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

UNIT III **3 Hours**

MANUFACTURING TECHNOLOGY

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

3 Hours

UNIT IV

AGRICULTURE AND IRRIGATION TECHNOLOGY

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

3 Hours

SCIENTIFIC TAMIL & TAMIL COMPUTING

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

Total: 15 Hours

Reference(s)

1. Dr.K.K.Pillay , Social Life of Tamils , A joint publication of TNTB & ESC and RMRL
2. Dr.S.Singaravelu , Social Life of the Tamils - The Classical Period, International Institute of Tamil Studies.
3. Dr.S.V.Subatamanian , Dr.K.D. Thirunavukkarasu, Historical Heritage of the Tamils, International Institute of Tamil Studies.
4. Dr.M.Valarmathi , The Contributions of the Tamils to Indian Culture, International Institute of Tamil Studies
5. Keeladi - 'Sangam City Civilization on the banks of river Vaigai' , Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu
6. Dr.K.K.Pillay, Studies in the History of India with Special Reference to Tamil Nadu.
7. Porunai Civilization, Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu
8. R.Balakrishnan , Journey of Civilization Indus to Vaigai, RMRL

பாடததிட்டததின நாகக்ம

1. சங்க காலத்தில் வரலொறு மறறும கலாசசாரை ஆவணங்களின ஒரு வடிவமாக,

மடபாண்டங்கள யதான கிராஃபிட்டிமய பகுபபாய்வு தசயதல.

2. சிலபபதிகாரத்தில கடடபபடட பமமட கடடுமானங்களின வவரங்கமளயும அவறறின கலாசசாரை ரக்கியதத்துவதமதயும பகுபபாய்வு தசயவதன றலம, சங்க காலத்தில மாமல்ர கறகளின கடடுமானப தாருடக்ள மறறும வரலொறறு சாழமல ஆராயதல.

3. சரத்திரங்கள பறறிய பணமடய அறிமவயும, தமழ சறகத்தில அதன

தாக்கதத்மதயும ஆராய்வது ஆகியமவ இபபாடத்திடடத்தின பாநாக்கம ஆகும.

கறறலின வளைவு

1. சங்க காலத்தில தநசஷ்த ததாழிலின ரக்கியதத்துவத்மதயும அதன கலாசசாரை ரக்கியதத்துவத்மதயும பாரிநது தகளளல.
2. பசாழர கால வவசாய மறறும நரபபாசன நமடராமறகளில அமணகள,

காளங்கள மறறும மதகுகளின ரக்கியதத்துவதத்மதப பாரிநது தகளளல.

3. சங்க காலத்தில ஈடடுப தாருடக்களில பயனபடுத்தபபடட கடடடக்கமல வடிவமமபபுகள மறறும கடடமமபபு கடடுமான ராமறக்மள ஆராயதல.
4. பணமடய தமழ கலாசசாரத்தில, கபபல கடடும கமல, கடல வரத்தகம மறறும பபாக்குவரத்தில அதன பங்மக ஆராய்தல.
5. தமழ ததாழியில அறிவியல தாழிறகளஞசியம மறறும தாழிலலகராதியின வளரசசிமயக கணடறிதல.

அலகு I நெசவு மற்றும் பானைத் தொழில்நுட்பம்: **3**

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

அலகு II வடிவமைப்பு மற்றும் கட்டிடத் தொழில்நுட்பம்: **3**

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

அலகு III உற்பத்தித் தொழில் நுட்பம்: 3

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

அலகு IV வேளாண்மை மற்றும் நீர்ப்பாசனத் தொழில் நுட்பம்: 3

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

அலகு V அறிவியல் தமிழ் மற்றும் கணித்தமிழ்: 3

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

TOTAL : 15 PERIODS

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

22EE401 POWER GENERATION, TRANSMISSION AND DISTRIBUTION 3 1 0 4

Course Objectives

- To understand the various aspects and functioning of conventional power generators.
- To understand the various types of transmission system and develop the mathematical models for line parameters.
- To compute the voltage regulation and efficiency using line parameters. To subsume the string efficiency.
- To understand the different types of insulators and underground cables.
- To understand distribution systems and substation layouts.

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

f. PO6.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

g. PO7.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

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Analyze the electro-mechanical energy conversion process in conventional generators.
2. Analyze the transmission line parameters.
3. Analyze the system performance of transmission lines.
4. Evaluate the different types of insulators and cables.
5. Evaluate the substation layout and lines in distribution systems.

Articulation Matrix

CO No	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2
1	2	2											3	
2	2	2				2	3							3
3	2	2					2						3	3
4	2	2					3						3	3
5	3	3				2							3	3

UNIT I **9 Hours**

POWER GENERATORS

Load curves-Power system factors-Power station choice and site selection-Steam power plants-Layout and working-Turbo-alternators-Hydroelectric power plants-Layout and working- Nuclear power plants-Layout andworking.

UNIT II **9 Hours**

TRANSMISSION LINE PARAMETERS AND MODELING

Resistance, Inductance and capacitance of single phase and three phase line - Stranded and bundled conductor

configurations - Symmetrical and unsymmetrical spacing - Transposition of line conductors - Double circuit lines -Skin and proximity effects.

UNIT III **9 Hours**

PERFORMANCE OF TRANSMISSION LINES

Regulations and Efficiency of Short Lines, Medium transmission lines by nominal T & Ž methods- Long Transmission line by Rigorous Solutions - ABCD Constant - Ferranti Effect - Corona Effect - Corona loss.

UNIT IV **9 Hours**

OVERHEAD LINES AND CABLES

Insulators - Types and comparison - Voltage distribution in insulator string - String efficiency - Methods of improving string efficiency- Sag in overhead lines- - Types - Capacitance - Grading of cables - Testing of cables

UNIT V **9 Hours**

DISTRIBUTION SYSTEMS

Primary and Secondary distribution networks-AC and DC distribution - single phase and three phase, 4-wiredistribution- System comparison - Substation equipment and layouts - Bus bar arrangements.

FOR FURTHER READING

Types of power station, Types of dam, Types of power reactor, Conversion of solar and wind energy into electric energy, types of towers, lines and cables, recent trends in power generation, transmission and distribution.

Total: 60 Hours

Reference(s)

1. B.R. Gupta Generation of Electrical Energy-7th edition, S.Chand Publishers, New Delhi,2017.
2. Leonard L. Grigsby , Electric Power Generation, Transmission, and Distribution, CRC Press, 2018.
3. Ailson P. de Moura, Adriano Aron F. de Moura, Ednardo P. da Rocha, Transmission of Electrical Energy-Overhead Lines, CRC Press, 2020.
4. I.J.Nagrath, D.P.Kothari, Power System Engineering, Tata McGraw Hill Ltd, New Delhi, 2017.
5. Kamaraju , Electrical Power Distribution Systems, Tata McGraw Hill Ltd, New Delhi, 2017.

22EE402 ELECTRICAL MACHINES II **3 0 2 4**

Course Objectives

- To understand the production of torque and EMF in Synchronous machine.
- To understand the construction, operation and characteristics of PMSM and BLDC.
- To understand the operation and characteristics of Servo Motor and its applications.
- To understand the construction, operation and characteristics of SRM.
- To estimate the performance of Stepper motor and Linear Induction motor.

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

d. PO4.Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Analyse the various types and characteristics of Synchronous Machines.
2. Design an equivalent circuit and analyse the performance of the PMSM and BLDC.
3. Select a suitable Servo motor for the given applications.
4. Evaluate the losses and efficiency of SRM.
5. Analysis the performance characteristics of Various Stepper Motor.

Articulation Matrix

CO No	PO 1	PO 2	P O3	PO 4	P O5	P O6	P O7	P O8	P O9	PO 10	PO 11	PO 12	PS O1	PS O2
1	3	2	2	3									2	2
2	3	2	2	3									3	2
3	2	1	2										2	2
4	2	2	1										3	2
5	3	3	2	3									3	2

UNIT I **9 Hours**

SYNCHRONOUS MACHINES

Construction Details – Types of Rotor – Operation in Motor and Generating Mode – Torque and EMF Equation – Voltage Regulation in Generator – Direct Loading method – Synchronizing and Parallel Operation – Synchronous condenser.

UNIT II **9 Hours**

PMSM AND BLDC

Construction and principle of operation – Types - EMF and torque equations - torque speed characteristics - Hall sensors - optical position sensors –Driver circuits for PMSM and BLDC. Speed control of PMSM and BLDC. Selection of BLDC for E Vehicles.

UNIT III **9 Hours**

SERVO MOTOR

Servo Mechanism, Types of Servo Motors – DC and AC - Characteristics of servo motor – Selection of servo – Position Control –Servo Drives.

UNIT IV **9 Hours**

SWITCHED RELUCTANCE MOTORS

Constructional features - Principle of operation - Torque equation -Power controllers - Control circuits for SRM - Torque speed Characteristics –SRM Drives.

UNIT V **9 Hours**

STEPPER MOTOR

Construction and Principle of operation - Variable reluctance stepper motor, Permanent magnet stepper motor, Hybrid stepper motor, Static and dynamic characteristics, Driver circuit, Applications and advantages.

FOR FURTHER READING

Power transformer, cogging torque and Flux weakening in PMSM.

LABORATORY

EXPERIMENTS

EXPERIMENT 1

The students will be able to select a suitable synchronous generator for power generating station based on the perform characteristics of the alternator.

15 Hours

EXPERIMENT 2

The students will be able to do position, speed and torque control in servo, stepper and switched reluctancemotor.

15 Hours

Total: 75 Hours

Reference(s)

1. D. P. Kothari and I. J. Nagrath, Electric Machines, Tata McGraw Hill Publishing Company Ltd, Fifth Edition,2017.
2. Berker Bilgin , James Weisheng Jiang, Ali Emadi, “Switched Reluctance Motor Drives: Fundamentals toApplications”, CRC Press; 1st edition ,April 2019.
3. Riazollah Firoozian Servo Motors and Industrial Control Theory, Springer International. March 2021.
4. Duanek Hanselman, Brushless Motors: Magnetic Design, Performance, and Control of Brushless DC andPermanent Magnet Synchronous Motors, -Man Press LLC 2019.
5. Chang-liang Xia, Permanent Magnet Brushless DC Motor Drives and Controls, Wiley Publications, April 2012.

22EE403 MEASUREMENTS AND INSTRUMENTATION 3 0 2 4

Course Objectives

- To understand the fundamental concepts of measuring instruments and Standards.
- To understand the operation of various analog and digital instruments.
- To infer the importance of various bridge circuits used for measuring electrical quantities.
- To understand the measurement of physical quantities such as temperature, pressure and flow.
- To learn the principle and working of various transducers and display devices.

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Interpret the functions of instrumental elements and evaluate the errors in the process.
2. Analyze the importance and working of analog and digital instruments.
3. Design a suitable bridge for the measurement of unknown resistance, Inductance and Capacitance.Apply suitable transducer for measuring non electrical quantities like temperature, pressure, flow and pH.
4. Apply the types of display devices to visualize the measured quantities.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2	1										1	
2	2	1	1										2	1
3	2	1	1										2	1
4	3	3	1										2	1
5	2	1	1										1	1

UNIT I 8 Hours

INTRODUCTION

Functional elements of an instruments, Static and dynamic characteristics, Errors in measurement, Techniques for reducing error, loading effect of instruments, Statistical evaluation of measurement data, Standards and calibration.

UNIT II 10 Hours

ANALOG AND DIGITAL INSTRUMENTS

Analog Instruments -Moving coil instruments: Permanent magnet moving coil instruments, Moving iron: attraction and repulsion type instruments- Single and Three phase watt meters and Energy meters, Digital Instruments-Digital voltmeter, Digital multimeter, Energy meter.

UNIT III 9 Hours

MEASUREMENT OF ELECTRICAL QUANTITIES

Measurement of Resistance: Kelvin double bridge, Wheatstone bridge, Measurement of inductance and capacitance: Maxwell, Anderson and Schering bridge, Earth Resistance Tester, Power Quality Analyzer.

UNIT IV **10 Hours**

TRANSDUCERS

Classification of transducers, Selection of transducers, Resistive, capacitive & inductive transducers, Piezoelectric and digital transducers, Measurement of Temperature: Thermocouples, Radiation and Optical pyrometer, pressure measurement, Flow measurement- ultrasonic and electromagnetic flow meter, pH measurement.

UNIT V **8 Hours**

DISPLAY DEVICES AND DATA ACQUISITION SYSTEMS

Analog CRO and Digital CRO, Mixed signal Oscilloscope, Time Synchronization, Recorders and event Loggers- Elements of Data Acquisition systems.

FOR FURTHER READING

Calibration of Meters, Smart sensors, Introduction to Indian standards and international standards for calibration.

LABORATORY EXPERIMENTS

EXPERIMENT 1

The students will be able to select a high accuracy measuring instrument by incorporating suitable calibrating method. **7 Hours**

EXPERIMENT 2

The students will be able to select the suitable passive element and find its value using bridges for electronic circuit design. **8 Hours**

EXPERIMENT 3

The students will be able to design a suitable measuring instrument to measure voltage, current and energy in anelectrical circuit. **7 Hours**

EXPERIMENT 4

The students will be able to select a suitable transducer for non-electrical parameter measurement. **8 Hours**

Total: 75 Hours

Reference(s)

1. A. K. Sawhney, A Course in Electrical & Electronic Measurements & Instrumentation, 19th edition DhanpatRai and Co, 2014.
2. Alan Morris, Reza Langari, Measurement and Instrumentation Theory and Application, Elseveir Publications,2020.
3. Sergey Yurish, Advances in Measurement and Instrumentation reviews,IFSA publishing,2019
4. Robert B Northrop,Instrumentation and measurements, Taylor and Francis,2014.
5. H. S. Kalsi, Electronic Instrumentation, Tata McGraw Hill, 3rd edition 2018.

22EE404 DIGITAL LOGIC CIRCUIT DESIGN 3 0 2 4

Course Objectives

- To acquire the basic knowledge of digital logic levels and digital electronic circuits
- To design and analyze the combinational logic circuits
- To design and analyze the sequential logic circuits

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

d. PO4.Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

e. PO5.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.

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

Course Outcomes (COs)

1. Analyze the weighted, non-weighted number systems and Codes
2. Analyze the boolean laws and K-Map for minimization of logic circuits
3. Design and analyze the combinational logic circuits
4. Design and analyze the sequential logic circuits
5. Design and analyze the synchronous & asynchronous counters, logic families and Programmable Logic Devices (PLDs)

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	1	1	2									1	1
2	3	2	3	2									2	1
3	1	3	2	3	2								2	2
4	1	2	3	3	2								2	2
5	1	2	2	3	2								3	2

UNIT I **6 Hours**

NUMBER SYSTEMS AND CODES

Introduction to Digital Systems , Review of Number Systems, Representation of signed numbers, Binary Arithmetic using 1s and 2s Complements, Codes and their types.

UNIT II **10 Hours**

BOOLEAN THEOREMS AND LOGIC REDUCTION

Logic gates, Basic Theorems and Properties of Boolean Algebra, Boolean Functions, AOI, NAND and NOR Implementation - Canonical and Standard Forms of representation, Karnaugh-Map Method

UNIT III **10 Hours**

COMBINATIONAL LOGIC CIRCUITS

Binary adders, Binary Subtractor, Parallel Binary Adders, BCD Adders, Encoder, Decoder, Comparator, Code Convertor, Multiplexers, Demultiplexers, Parity Generator and Checker

UNIT IV **10 Hours**

SEQUENTIAL LOGIC CIRCUITS

Gated Latches & Flip Flops- Level and Edge triggered flip-flops, Flip Flop Conversion. Shift registers, General model of sequential circuits- Mealy/Moore models -Excitation table- State table- State diagram

UNIT V **9 Hours**

COUNTERS, LOGIC FAMILIES AND PLDS

Design of Synchronous & Asynchronous Counters, shift register counters, Hazards in logic circuits, Logic Families, Programmable Logic Devices (PLDs)

1 **3 Hours**

EXPERIMENT 1

Design and implementation of Boolean logic functions using universal gates

2 **3 Hours**

EXPERIMENT 2

Implementation of binary adder and subtractor using logic gates.

3 **3 Hours**

EXPERIMENT 3

Design and implementation of encoder & decoder circuit using logic gates

4 **3 Hours**

EXPERIMENT 4

Design and implementation of Multiplexer & Demultiplexer circuit using logic gates

5 **3 Hours**

EXPERIMENT 5

Design and implementation of a 2 bit magnitude comparator using logic gates.

6 **3 Hours**

EXPERIMENT 6

Design and implementation of odd/even parity generator and checker using logic gates

7 **3 Hours**

EXPERIMENT 7

Design and implementation of code converters using logic gates.

(i) Binary to gray

(ii) BCD to excess-3 code

8 **3 Hours**

EXPERIMENT 8

Conversion of one flip-flop into another flipflop.

9 **3 Hours**

EXPERIMENT 9

Design and implementation of Shift register (SISO, SIPO,PIPO) using Flip flops

10 **3 Hours**

EXPERIMENT 10

Design and implementation of Up and down counters using flip flops.

Total: 75 Hours

Reference(s)

1. M.Morris Mano, Michael D Ciletti Digital Design 4th edition Pearson, 2011.
2. Thomas L.Floyd, Digital Fundamentals, Prentice Hall, 11th Edition, 2015.
3. A.Anand Kumar, Fundamentals of Digital Circuits, 4th Edition PHI Learning Private Limited, 2016.
4. Charles H. Roth, Jr., Fundamentals of Logic Design, 7th Edition Reprint, Brooks/Cole, Pacific Grove, US,2014.
5. Ronald J. Tocci, Digital System Principles and Applications, 10th ed., Pearson Education, 2009.

22EE405 EMBEDDED SYSTEM 3 0 2 4

Course Objectives

- To understand the overview of Embedded System Architecture.
- To apply the Embedded C programming concepts in Microcontroller.
- To analyse embedded communication protocols.

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

e. PO5.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.

g. PO7.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

h. PO8.Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice

j. PO10.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

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Understand the 8086 architecture and write ALP for 8086 processor.
2. Understand hardware and software architectures of Embedded Systems
3. Analyse the special features and architecture of TIVA C series microcontroller.
4. Analyse and program different communication protocols used for Embedded Networking.
5. Design embedded applications by interfacing the OFF-chip peripherals with the microcontroller.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	3	2										3	2
2	1	2	3										3	2
3	2	3	2										3	3
4	3	2	2										3	3
5	1	3	2										3	3

UNIT I **9 Hours**

8086 MICROPROCESSOR

8086 Architecture - 8086 Instruction set -8086 Addressing modes – 8086 ALP-Interrupts.

UNIT II **9 Hours**

INTRODUCTION TO EMBEDDED SYSTEM

Categories of embedded systems, Specialties of embedded systems, Recent trends in embedded systems, Hardware architecture, Software architecture, Communication software, Process of generation of executable image, Development/testing tools.

UNIT III **9 Hours**

TIVA-C MICROCONTROLLER & PROGRAMMING IN C

TIVA-C Microcontroller Architecture and Its memory map, GPIO Programming, WDT Programming, Interrupt Programming, LPM Programming

UNIT IV **9 Hours**

COMMUNICATION PROTOCOLS

UART, ADC, PWM, Timer, I2C, SPI.

UNIT V **9 Hours**

OFF-CHIP PERIPHERAL INTERFACING AND PROGRAMMING

RTC Interfacing, Bluetooth module interfacing, Analog Sensor interfacing, Motor Interfacing.

1 **4 Hours**

EXPERIMENT 1

16-bit, 32-bit Arithmetic Operations (8086)

2 **4 Hours**

EXPERIMENT 2

String Operations (8086)

3 **5 Hours**

EXPERIMENT 3

Sorting operation (8086)

4 **5 Hours**

EXPERIMENT 4

Flashing of LEDS using Shift Register

5 **6 Hours**

EXPERIMENT 5

Interfacing DC and Stepper Motor

6 **6 Hours**

EXPERIMENT 6

Interfacing temperature sensor

Total: 75 Hours

Reference(s)

1. Ray K & Bhurchandi K.M, "Advanced Microprocessors and Peripherals: Architecture, Programming and Interface", 3rd Edition, McGraw Hill, New Delhi, 2012.
2. Prasad.K.V.K.K, “Embedded Real-Time Systems: Concepts, Design & Programming”, Dream tech press, 2013.
3. Muhammad Ali Mazidi, Sarmad Naimi and Sepehr Naimi, “TI ARM Peripherals Programming and Interfacing Using C Language”, Pearson Education, 2014.
4. Jonathan W. Valvano, “Embedded Systems: Introduction to Arm® Cortex™-M Microcontrollers”, 5th edition, ISBN: 978-1477508992, 2014.
5. Embedded System Design Using TIVA, TI University Program, Learning Material.

22HS007 ENVIRONMENTAL SCIENCE 2 0 0 0

Course Objectives

- Understand the interdisciplinary and holistic nature of the environment
- Identify the significance of natural resources and environment on the quality of life and stimulate the quest for sustainable development
- Assess the socio-economic, political and ethical issues in environmental science

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

g. Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

Course Outcomes (COs)

1. Show the importance of interdisciplinary nature of environment studies, uses and exploitation of natural resources
2. Demonstrate the different types of ecosystems and biodiversity, its values and also role of professionals in protecting the environment from degradation
3. Assess the existing environmental challenges related to pollution and its management
4. Select suitable strategies for sustainable management of components of environmental science
5. Compare the impacts of population and human activities on environment

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	1	2												
2	1	1												
3	2	2					1							
4	1													
5	2													

UNIT I **6 Hours**

NATURAL RESOURCES

Forest resources: Use - over exploitation - deforestation - case studies. Water resources: Use - over utilization of surface and ground water - conflicts over water. Mineral resources: Use - exploitation - environmental effects of extracting and using mineral resources - case studies. Food resources: Effects of modern agriculture - fertilizer-pesticide problems (eutrophication, blue baby syndrome, biomagnification). Energy resources: renewable (solar, wind, and hydro).

UNIT II **6 Hours**

ECOSYSTEMS AND BIODIVERSITY

Concept of an ecosystem: Structure and function of an ecosystem - producers - consumers - decomposers - food chains - food webs and ecological pyramids - Types of ecosystem: Introduction - characteristic features: desert ecosystem. Biodiversity - value of biodiversity - threats to biodiversity - endangered and endemic species - Conservation of biodiversity: In-situ and ex-situ conservation of biodiversity.

UNIT III **6 Hours**

ENVIRONMENTAL POLLUTION

Pollution: Definition - causes - effects - control measures of air pollution - water pollution : (Sewage water treatment by activated sludge and trickling filter process) - noise pollution- thermal pollution. Disaster management: causes - effects - control measures of floods - Earthquake

UNIT IV **7 Hours**

SOCIAL ISSUES AND ENVIRONMENT

Sustainable development : Definition - Unsustainable to sustainable development - solid waste management - causes - effects - 5R Principles (landfills, incineration, composting). Water conservation - rain water harvesting - watershed management. Climate change - global warming - acid rain - ozone layer depletion. E-waste.

UNIT V **5 Hours**

HUMAN POPULATION AND ENVIRONMENT

Human population: Population growth - characteristics - variation among nations - population explosion - value education - HIV / AIDS. Role of information technology in environment and human health - occupational safety and health administration (OSHA)

Total: 30 Hours

FOR FURTHER READING

Human rights:Biomedical waste -Identification of adulterants in food materials

Reference(s)

1. Anubha Kaushik, C.P. Kaushik, Environmental Science and Engineering , 4th Multi Colour Edtion, New Age International Publishers, New Delhi, 2014
2. Raven, P.H., Hassenzahl, D.M. & Berg, L.R. 2012. Environment. 8th edition. John Wiley & Sons
3. T. G. Jr. Miller, S. Spoolman, New Environmental Science, 14th Edition, Wadsworth Publishing Co, New Delhi, 2014
4. Pepper, I.L., Gerba, C.P. & Brusseau, M.L. 2011. Environmental and Pollution Science. Academic Press
5. A. K. De, Environmental Chemistry, 7th Edition , New age international publishers, New Delhi, 2014

22HS008 ADVANCED ENGLISH & TECHNICAL EXPRESSION 0 0 2 1

Course Objectives:

- To enable students to achieve proficiency in academic writing.
- Effectively use the language to persuade others.
- Appreciate the nuances of the language and engage an audience.
- Use advanced tools of language to improve communicative competence.
- Prepare for professional demands at the workplace.
- Give concrete expression to the plans and goals.

Course Outcomes:

1. Understand the clarity in articulating the objectives and aims and improved proficiency in using the English language
2. Communicate effectively and with good interpersonal skills; speak in public, engage the audience, and lead a group discussion
3. Critically evaluate the ethics of persuasive appeals and confidence to influence opinion
4. Analyse a specific piece of information; take in what is read, and use good writing techniques with proper grammar and syntax in all formal situations
5. Create awareness and empathy to emotional signals in communication

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1									2	3				
2									2	3				
3									2	3				
4									2	3				
5									2	3				

UNIT – 1 - CREATIVE EXPRESSION 15 Hours

Proposals & Grant applications, Argumentative essays & editorials, Sales Pitches, Campaigning, Commercials/advertisements, effectively answering the famous interview question: 'Why should we hire you?' Sentence and paragraph formation - Rhetorical questions - Emphasis & effective repetition - Empathetic expression, knowing the audience, capturing attention - Creating Memes, Comic Strips, Stand-up comedy, Caption writing, and Limericks, Vocabulary and slang words for comedy - Similes & Metaphors - Homophones, homonyms, alliteration, wordplay

UNIT 2 - FORMAL EXPRESSION 15 Hours

Writing: Action plans, Cover letters, Mind-Mapping, Paragraph writing Logical reasoning - SVA - Advanced level - Style: Clarity, Concision, Coherence, Evocativeness, Efficacious Vocabulary - Conditional Clause - Be verbs- Tenses- advanced - Opening and closing sentences - Action plans, Anecdotal references, order of communication/ narration, complete communication- Wh-questions - Effective beginning and closing - Rhetorical questions - Appraising target audience - Pronunciation, Enunciation, Tone, Pace and Volume. - Writing: SOPs, Research Objectives, Thesis Statement, Indexing, Scholarly Articles, Academic Writing,

Executive Summary, Survey Questionnaires, Citations and Bibliography - Reading: Quantitative & qualitative analysis, Analysis and paraphrasing of reference materials Speaking: Commentate live events, give instructions to operate machines/ conduct experiments Listening: Informational listening, Reflective listening, - Discriminative listening - Connective words - Prefixes and Suffixes - Quoting and paraphrasing Proofreading - Directed writing and writing formats - Note taking - Active verbs.

Reference(s)

Total: 30 Hours

1. Sangeeta Sharma et.al. Communication Skills for Engineers and Scientists, PHI Learning Pvt. Ltd, 2011
2. Murphy, Raymond. English Grammar in Use: A Self-Study Reference and Practice Book for Intermediate Students: with Answers. Cambridge: Cambridge University Press, 1985.
3. Business Correspondence and Report Writing by Prof. R.C. Sharma & Krishna Mohan, Tata McGraw Hill & Co. Ltd., 2001
4. Personality Development, Harold R. Wallace & L.Ann Masters, Cengage Learning, New Delhi
5. Developing Communication Skills by Krishna Mohan, Meera Bannerji-Macmillan India Ltd. 1990, Delhi
6. English Grammar, Composition and Usage by N. K. Agrawal & F. T. Wood, Macmillan India Ltd., New Delhi

22EE501 POWER SYSTEM ANALYSIS 3 0 2 4

Course Objectives

- To apply the concept of per unit systems in power system computations.
- To develop algorithms for power system planning.
- To understand the application of power system matrices.
- To understand the concept of symmetrical components.
- To analyze the stability of given network.

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

d. PO4.Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

e. PO5.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.

i. PO9.Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

j. PO10.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

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complexengineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Apply the concept of per unit systems to construct the reactance diagram of the given power system network.
2. Evaluate the power flow and losses in a power system network using non-linear iterative solution methods.
3. Apply the concepts of bus impedance matrix to analyze the effects of balanced faults in power system.
4. Apply the concept of symmetrical components to analyze the effects of unbalanced faults in power system.
5. Evaluate the stability of the power system during transient operations.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	3			2				1	2			3	2
2	3	3		1	2				1	2			3	2
3	3	3		2									3	2
4	3	3		2									3	2
5	3	3		2	2				1	2			3	2

UNIT I **9 Hours**

POWER SYSTEM MODELING

Single line diagrams -Per unit system -Per unit impedance/ reactance diagrams -Formation of network matrices - Y bus formation using inspection and singular transformation -Z bus formation using step-by-step building algorithm method.

UNIT II **8 Hours**

LOAD FLOW ANALYSIS

Bus classification - Load flow equations and methods of solution -Slack bus concept -Gauss Seidal, Newton Raphson, Fast decoupled methods for load flow studies.

UNIT III **9 Hours**

FAULT ANALYSIS - SYMMETRICAL FAULTS

Importance of short circuit analysis - assumptions in fault analysis - analysis using Thevenin's theorem - Z-bus building algorithm - fault analysis using Z-bus - computations of short circuit capacity, post fault voltage and currents – Selection of Circuit breakers.

UNIT IV **10 Hours**

FAULT ANALYSIS - UNSYMMETRICAL FAULTS

Introduction to symmetrical components - sequence impedances - sequence circuits of synchronous machine, transformer and transmission lines - sequence networks analysis of single line to ground, line to line and double line to ground faults using Thevenin's theorem and Z-bus matrix - Indian Standards for Short Circuit analysis IS- 13234.

UNIT V **9 Hours**

POWER SYSTEM STABILITY

Steady state and transient stability -Swing equation and its solution method (Runge – Kutta Method) -Equal area criterion -Factors affecting stability and methods of improving stability.

FOR FURTHER READING

Overview of Indian power scenario- Electricity Deregulation-Electricity Pricing

1 **7 Hours**

EXPERIMENT 1

Formation of Bus Admittance Matrix and Bus Impedance Matrix

2 **9 Hours**

EXPERIMENT 2

Power Flow analysis of power systems network

3 **7 Hours**

EXPERIMENT 3

Economic Dispatch in Power Systems

4 **7 Hours**

EXPERIMENT 4

Transient Stability Analysis

Total: 75 Hours

Reference(s)

1. I.J. Nagarath, D.P. Kothari, Modern Power System Analysis, Tata McGraw Hill Publishing Company, New Delhi, 2022.
2. J. Duncan Glover, Mulukutla S. Sarma, Thomas J. Overbye, Power System Analysis and Design, Cengage Learning, 2019.
3. Hadi Saadat, Power System Analysis, PSA Publishers, New Delhi, 2013.
4. P.Kundur, Om P. Malik, Power System Stability and Control, Tata McGraw Hill Book Company, New Delhi, 2022.
5. P. Venkatesh, B.V. Manikandan, S. Charles Raja, A. Srinivasan, Electrical Power Systems Analysis, Security and Deregulation, PHI Learnin Private Limited, New Delhi, 2017.

22EE502 POWER ELECTRONICS 3 0 2 4

Course Objectives

- To analyze the static and switching characteristics of power semi-conductor devices.
- To understand the operation of controlled rectifiers.
- To understand and analyze the various types of choppers.
- To evaluate the operation, characteristics and performance parameters of Inverters.
- To understand the operation of ac-ac converters.

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

d. PO4.Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

e. PO5.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.

i. PO9.Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

j. PO10.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

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complexengineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Assess the static and dynamic characteristics of power semiconductor devices with the protection circuits.
2. Evaluate the input and output parameters of controlled rectifiers with R, RL and RLE Load.
3. Apply the various converter topologies to design and analyze the switched mode regulators
4. Analyze the operation of inverter topologies with different PWM schemes.
5. Analyze the performance parameters of AC- AC converters.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	1		2	2				2	2			1	
2	3	2	1	2	2				2	2			3	
3	3	2	1		2				2	2			3	1
4	3	2	1	2	2				2	2			3	1
5	3	2		2	2				2	2			3	1

UNIT I **9 Hours**

POWER SEMI-CONDUCTOR DEVICES

Construction - Operation - Static and Dynamics characteristics of Power Diode- SCR-DIAC - TRIAC- GTO - Power BJT - MOSFET – IGBT- Ratings of Devices - Protection of Devices.

UNIT II **9 Hours**

CONTROLLED RECTIFIERS

Single Phase and Three Phase Half and Fully controlled rectifier with R, RL, RLE Load - Effect of Freewheeling Diode -Continuous and Discontinuous Mode of operation - Performance Analysis - Dual converter-Applications.

UNIT III **9 Hours**

CHOPPERS

Classification - Control strategies – Switches Mode Regulators – Non Isolated DC-DC Converters: Buck, Boost, Buck-Boost and Sepic Converters- Isolated DC-DC Converters: Flyback and Forward Converters-Performance analysis - Applications.

UNIT IV **10 Hours**

INVERTERS

Single Phase inverters and Three Phase Voltage Source Inverters - Single phase and Three Phase Current Source Inverters – Multilevel inverter-Types-Performance analysis - PWM techniques-Space Vector PWM Techniques - Analysis of Harmonic Distortion- Applications.

UNIT V **8 Hours**

AC-AC CONVERTERS

Single Phase and Three Phase AC Voltage Controllers-Performance Analysis - Matrix converters-Applications.

EXPERIMENT 1

Select a power switch and design a suitable dc-dc and ac-dc power converters. **10 Hours**

EXPERIMENT 2

Design an inverter circuit with suitable PWM pulse technique. **10 Hours**

EXPERIMENT 3

Design an Ac-Ac converter for Energy Conversion Systems. **10 Hours**

Total: 75 Hours

Reference(s)

1. Muhammad H.Rashid, ‘Power Electronics Circuits, Devices & Applications’, 4th Edition, Pearson India, 2018.
2. Ned Mohan, Tore. M. Undeland, William. P. Robbins, ‘Power Electronics: Converters, Applications and Design’, 3rd Edition Wiley India, NewDelhi, 2012.
3. M.D.Singh & K.B Khanchandani, ‘Power Electronics’, 2nd Edition, Tata Mc Graw Hill Publishing Co.Ltd., New Delhi, 2017.
4. R. W. Erickson and D. Maksimovic, “Fundamentals of Power Electronics”, Springer Science & Business Media, 2007.
5. José Rodríguez, , Jih-Sheng Lai, and Fang Zheng Peng, ‘Multilevel Inverters: A Survey of Topologies, Controls, and Applications’, IEEE Trans. Ind. Electron., Vol. 49, No. 4, August 2002.

22EE503 OPTIMIZATION IN ENGINEERING DESIGN 3 1 0 4

Course Objectives

- To understand the fundamentals of various techniques in optimization.
- To understand the optimization algorithms for single variable.
- To learn the multivariable optimization in engineering design.
- To know the concepts of multi objective and constrained optimization.
- To apply the knowledge of optimization in electrical engineering.

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complexengineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Apply optimization techniques for solving single variable design problems.
2. Apply the concept of mathematical models to solve multi variable optimization problems.
3. Evaluate the transformation methods to give solutions to constrained optimization problem.
4. Apply optimization techniques to demonstrate multi objective optimization
5. Select and apply suitable techniques to solve optimization problems.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2											2	2
2	3	2											2	2
3	3	2											2	2
4	3	2											2	2
5	3	2											2	3

UNIT I **9 Hours**

INTRODUCTION

Optimal Problem Formulation: Design variables, Constraints, Objective function, Variable bounds, Classification of optimization algorithms, Single -variable optimization algorithms- Optimality criteria. Bracketing methods; Exhaustive search method, Bounding phase method. Region Elimination methods; Interval Halving Method, Fibonacci Search method.

UNIT II **9 Hours**

MULTI VARIABLE OPTIMIZATION

Optimality criteria, Unidirectional search, Direct Search methods- Box' Evolutionary Optimization method, Simplex Search method. Gradient based methods- Cauchy's (Steepest Descent) Method, Newton's Method.

UNIT III **9 Hours**

CONSTRAINED OPTIMIZATION ALGORITHMS

Kuhn- Tucker Conditions, Transformation Methods- Penalty function method and Method of multipliers. Sensitivity analysis, Direct search for constrained minimization; variable elimination method, complex search method, Random search method, Generalized reduced gradient method, Gradient projection method.

UNIT IV **9 Hours**

MULTI OBJECTIVE OPTIMIZATION PROBLEMS

Basic concepts – Non dominated solutions – preferences structure, basic solution approach – Weighted sum approach, Random weight approach, adaptive weight approach. Distance method, concepts – calculation of distance. Compromise approach and goal programming approach.

UNIT V **9 Hours**

OPTIMIZATION APPLICATIONS

Case study- Distance optimization, Transmission loss minimization, Machine dimension optimization.

FOR FURTHER READING

Dynamic Programming, Integer Programming, Evolutionary techniques.

Total: 60 Hours

Reference(s)

1. Rao, S.S., "Engineering Optimization Theory and Practice ", Wiley Online Library., Fifth Edition,2019.
2. K. Deb, “Optimization for Engineering Design – Algorithms and Examples”, Prentice-Hall of India Pub., 2012
3. Donald A. Pierre.,"Optimization Theory with Applications", Courier Corporation, 2012
4. Ashok D. Belegundu, Tirupathi R. Chandrupatla, “Optimization Concepts and Applications in Engineering” , Cambridge University Press, 2019.
5. Joaquim R. R. A. Martins and Andrew Ning. “Engineering Design Optimization”, Cambridge University Press, 2021.

22EE504 CONTROL SYSTEMS **3 1 0 4**

Course Objectives

- To understand the basic concepts of open loop and closed loop control systems.
- To analyze the given system in time domain.
- To understand the concept of frequency domain analysis
- To understand the concept of stability of system
- To design the compensator for different control systems

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

d. PO4.Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Develop a mathematical model of a physical system and compute the transfer function using Block diagram reduction technique and Signal flow graph.
2. Analyze the performance of first and second order systems and compute the steady state error for different test signals.
3. Analyze the frequency response of a given system
4. Examine the stability of a given system using various methods
5. Design a lag, lead and lag lead compensator for open loop system and examine a system using state variable techniques.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2											2	2
2	3	2	2										2	2
3	3	2		2									2	2
4	3	2	2	2									2	2
5	2	2	2	2									2	2

UNIT I **9 Hours**

MATHEMATICAL MODEL OF PHYSICAL SYSTEMS

Basic elements in control systems Open and closed loop systems with examples Mathematical representation of systems Transfer function mechanical and electrical systems, Electrical analogy of mechanical systems Block diagram reduction techniques Signal flow graphs.

UNIT II **9 Hours**

TIME DOMAIN ANALYSIS

Standard test signals Time response of first order and second order systems for unit step test signals Time domain specifications-Steady state response Static error constants steady state error Effects of proportional derivative, proportional integral systems.

UNIT III **8 Hours**

FREQUENCY DOMAIN ANALYSIS

Frequency response of systems Frequency domain specifications Correlation between frequency domain and time domain specifications frequency domain analysis using Bode plot, Polar plot.

UNIT IV **10 Hours**

STABILITY ANALYSIS OF CONTROL SYSTEM

Concepts of stability Necessary conditions for Stability Characteristics equation Location of roots in S plane for stability Routh Hurwitz criterion Nyquist stability criterion Root Locus technique- Relative Stability

UNIT V **9 Hours**

COMPENSATOR DESIGN AND STATE VARIABLE ANALYSIS

Compensators: Deign of Lag compensator Lead compensator Lag-lead compensator (using Bode plot) Concept of state, state variables, and state model, Controllability and observability tests.

Total: 60 Hours

Reference(s)

1. I.J. Nagrath and M. Gopal, Control System Engineering, New Age International Publisher, 2011.
2. M Gopal, Control Systems Principles and Design, Tata McGraw hill, New Delhi, 2012
3. K.Ogatta, Modern Control Engineering, Pearson Education, NewDelhi, 2015
4. Benjamin C. Kuo, Automatic Control Systems, Prentice-Hall of India Pvt. Ltd.2014
5. Norman S. Nise, Control Systems Engineering, 4th edition, New York, John Wiley, 2003

22EE507 MINI PROJECT I **0 0 2 1**

Course Objectives

- Identify the problem statement and apply the engineering concepts to find the solution.
- Improve the analysing capability of the students.
- Increase the exuberance in finding the solution to various problems.

Course Outcomes (COs)

1. Formulate a real-world problem, identify the requirement, and develop the design solutions.
2. Identify technical ideas, strategies, and methodologies.
3. Utilize the new tools, algorithms, and techniques that contribute to obtaining the solution of the project.
4. Test and validate through conformance of the developed prototype and analysis of the cost-effectiveness.
5. Prepare the report and present oral demonstrations.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	1	2	1	1	2			2	2	2			2	2
2	1	2	1	1	2			2	2	2			2	2
3	1	2	1	1	2			2	2	2	2		2	2
4	1	2	1	1	2			2	2	2	2		2	2
5	1	2			2			2	2	2			2	2

Total: 30 Hours

22EE601 POWER SYSTEM PROTECTION AND SWITCH GEAR 3 0 0 3

Course Objectives

- To understand the different types of protection schemes in power system
- To understand the construction and operating principle of protective relays
- To gain knowledge on transmission line and apparatus protection schemes
- To understand the concept of arc phenomena, arc interruption and lightning arresters
- To illustrate the construction and operating principle of circuit breakers

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

f. PO6.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

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Analyze the causes of different types of faults and choose a suitable protection scheme
2. Analyze the operating principle of protective relays
3. Apply suitable protective schemes for electrical apparatus
4. Examine the circuit interruption schemes for power systems
5. Outline the performance of different types of circuit breakers

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3					1							2	
2	3					2							3	1
3	3					2							2	2
4	3	2				2							2	1
5	3					3							1	2

UNIT I **8 Hours**

INTRODUCTION TO PROTECTION SCHEMES

Principles and need for protective schemes, Nature and causes of faults, primary and backup protection, Electromagnetic relays, Comparison between static and electromagnetic relays, Step and Touch potential, Zones of protection, Power System Earthing.

B.E. - EEE | Minimum Credits to be earned: 163 | Regulations 2022

UNIT II **10 Hours**

PROTECTIVE RELAY

Non directional and directional over current relays, Static and numerical over current relays, Distance relay - Impedance, reactance and mho relays, Differential and pilot relaying schemes, Auto reclosing and synchronizing.

UNIT III **9 Hours**

APPARATUS AND LINE PROTECTION

Alternator, transformer, induction motor, bus bar and feeder protection schemes, CTs and PTs and their applications in protection schemes, microprocessor based protective schemes

UNIT IV **8 Hours**

THEORY OF CIRCUIT INTERRUPTION

Physics of arc phenomena and arc interruption, Restriking voltage, Recovery voltage, rate of rise of restriking voltage, resistance switching, current chopping and interruption of capacitive current, lightning arresters and its types.

UNIT V

CIRCUIT BREAKERS **10 Hours**

Introduction- Rating of Circuit Breakers, Types of Circuit Breakers-Miniature, Earth leakage, Air blast, Air break, oil, SF6 and Vacuum circuit breakers with advantages and disadvantages, High voltage dc circuit breakers- Maintenance and Testing of circuit breakers-Recent developments in protective relays.

Total: 45 Hours

Reference(s)

1. Badri Ram, D.N.Viswakarma "Power system Protection and switchgear", Tata Mcgraw Hill, Private Limited, New Delhi, 2013.
2. Bhaveshbhalja, R.P. Maheshwari, Nilesh G. Chothani, "Protection and Swtichgear", Oxford University press, 2014.
3. Sunil S. Rao, "Switchgear Protection and Power Systems", Khanna publishers, New Delhi, 13th Edition, Reprint 2008.
4. V.K.Metha and Rohit Metha "Principles of power system", S. Chand company Ltd, 2011.
5. Wadhwa C L, "Electrical Power Systems", New age International (P) Ltd., Sixth Edition, 2010.
6. Bo, Z.Q., Lin, X.N., Wang, Q.P. et al. Developments of power system protection and control(2016).

22EE602 DIGITAL SIGNAL PROCESSING 3 1 0 4

Course Objectives

- To understand the signals and systems and their mathematical representation in time/frequency domain.
- To analyze the discrete time systems using Z-transform and Inverse Z-transform.
- To implement the discrete time systems in Discrete Fourier Transform using Fast Fourier Transform algorithm.
- To design FIR filters with its response and obtaining its realization structure.
- To design IIR filters with its response and obtaining its realization structure.

Programme Outcomes (POs)

a. PO1: Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. PO2: Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences
c. PO3: Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
d. PO4: Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
f. PO6: 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.
m. PSO1: Measure physical parameters for real time industrial applications by identifying appropriate sensors and designing suitable conditioning circuits.
n. PSO2: Develop and implement advanced control schemes for the next level of automation in multiple platforms using industrial controllers.

Course Outcomes (COs)

1. Analyze different types of Signals and Systems with its performance
2. Analyze the given discrete time system using Z-transform
3. Apply DFT for a given discrete time system for finding its system characteristics
4. Evaluate FIR filter with its response and construct its realization structure
5. Evaluate IIR filters for given specifications by following the suitable design procedures

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	2	2	2		1							2	2
2	2	3	3			1							3	2
3	2	2	2	2		1							2	2
4	2	2	2	2		1							2	2
5	2	2	2	2		1							2	2

UNIT I **10 Hours**

SIGNALS AND SYSTEMS

Classification of Systems: Continuous, Discrete, Linear, Causal, Stability, Dynamic, Recursive, Time Variance Systems; Classification of Signals: Continuous and Discrete, Energy and Power; Mathematical representation of Signals; Mathematical Operation of Signals; Sampling Theorem, Sampling techniques, Quantization, Quantization error, Nyquist rate, Aliasing effect.

UNIT II **9 Hours**

DISCRETE TIME SYSTEM ANALYSIS

Z-transform and its properties, Inverse Z-transforms; Difference equation - Solution by Z-transform, Application to Discrete Systems - Stability analysis, Frequency response - Convolution - Discrete Time Fourier transform, Magnitude and Phase representation.

UNIT III **8 Hours**

DISCRETE FOURIER TRANSFORM

Discrete Fourier Transform- properties, magnitude and phase representation - Computation of DFT using FFT algorithm - DIT & DIF using radix 2 FFT - Butterfly structure.

UNIT IV **10 Hours**

DESIGN OF FIR DIGITAL FILTERS

Finite Impulse Response (FIR) design: Amplitude and phase responses of FIR filter - Linear phase characteristics - Need and choice of windows - Windowing Techniques: Rectangular, Hamming and Hanning;[Realization of FIR filter using direct, Cascade and lattice structures]

UNIT V **8 Hours**

DESIGN OF IIR DIGITAL FILTERS

Realization of IIR filters using direct, cascade and parallel forms, Design of analogue Butterworth and Chebyshev Filters. Design of IIR digital filters using impulse invariance technique, bilinear transform Realization of IIR filters using direct, cascade and parallel forms.

Total: 60 Hours

Reference(s)

1. J.G. Proakis and D.G. Manolakis, 'Digital Signal Processing Principles, Algorithms and Applications', Pearson Education, New Delhi, PHI, Fourth Edition, 2014.
2. S.K. Mitra, 'Digital Signal Processing - A Computer Based Approach', McGraw Hill Edu, 2011.
3. Tarun Kumar Rawat, Digital Signal Processing, Oxford University Press, 2015.
4. Richard G. Lyons, D. Lee Fugal, The Essential Guide to Digital Signal Processing, Pearson Education, 3rd Edition, 2014.
5. S. Salivahanan, A.Vallavaraj, Gnanapriya, Digital Signal Processing, McGraw-Hill, 2nd Edition, 2011.
6. Alan V. Oppenheim, Ronald W. Schafer and John R. Buck, Discrete - Time Signal Processing, Pearson Education, New Delhi, 2013.

22EE603 RENEWABLE AND DISTRIBUTED ENERGY SOURCES 2 0 2 3

Course Objectives

- To Understand the Conventional and non-conventional energy resources.
- To impart knowledge on solar and wind energy harvesting in various forms and its technologies.
- To explore the processes in bioenergy conversion system and other renewable energy sources.
- To Familiarize the concept of distributed generation and installation.
- To Analyze the impact of grid integration of Renewable energy sources.

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

d. PO4.Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

g. PO7.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

n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Analyze the energy scenario and its impact on economic and social development.
2. Examine the solar energy and wind energy with various measurement techniques and factors affecting them.
3. Apply the energy conversion techniques in bioenergy and other renewable energy systems.
4. Interpret the need for distributed generation and installation.
5. Analyze the grid integration with conventional and non-conventional energy resources

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2					3							2
2	3	2	2	2			3							2
3	2		2	2			3							2
4	2		2	2			3							2
5	3	2					3							2

UNIT I **6 Hours**

INTRODUCTION

Energy scenario: global and national energy scenario. Renewable Energy potential: Global and national. Classification of RE technologies: Stand alone, grid connected and hybrid - Renewable Energy Scenario in India and

around the World - Role of energy in economic development and social transformation, Government policies and schemes to promote renewable energy implementations.

UNIT II **6 Hours**

SOLAR AND WIND ENERGY

Solar Radiation - Measurements of Solar Radiation - Flat Plate and Concentrating Collectors - Solar heating and cooling techniques - Solar thermal plant - Solar Photovoltaic - Solar Cells and Modules-Types- factors affecting solar power generation - Solar PV Applications- Wind Data and Energy Estimation - site selection - wind resource assessment - Types of Wind Energy Systems - factors influencing wind - wind shear - Safety and Environmental factors.

UNIT III **6 Hours**

BIOENERGY AND OTHER RENEWABLE ENERGY SOURCES

Biomass resources and their classification - biomass direct combustion-biomass gasifiers - Biomass conversion processes - Biogas plants - Digesters - Ethanol production - Biodiesel - Cogeneration - Electricity generation through biomass and biogas Systems-Hydropower - Types, site selection, construction, environmental issues. geothermal energy - site selection, geothermal power plants. Hydrogen energy storage system - Fuel cell - types - construction and applications

UNIT IV **6 Hours**

DISTRIBUTED GENERATIONS (DG)

Concept of distributed generations-topologies-selection of sources– Current scenario in distributed generation – Planning of DGs – Siting and sizing of DGs – Optimal placement of DG sources in distribution systems- Energy Storage elements: Batteries, ultra-capacitors, flywheels- capacitive power plants.

UNIT V **6 Hours**

CHALLENGES WITH GRID INTEGRATION

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

FOR FURTHER READING

Tidal energy -hybrid power generation system. - Concept of micro-grids, Control &, Protection of micro-grids, Case studies, Introduction to smart micro grids.

Total: 30 Hours

LABORATORY EXPERIMENTS

EXPERIMENT 1

Forecasting of solar irradiance temperature and wind velocity using weather monitoring station. **6 Hours**

EXPERIMENT 2

Performance evaluation of solar water pumping system. **6 Hours**

EXPERIMENT 3

Performance evaluation of natural convection solar dryer with different food processing. **6 Hours**

EXPERIMENT 4

Design of solar PV boost converter using MPPT technique. **6 Hours**

EXPERIMENT 5

Design and simulation of Solar PV-wind hybrid system.. **6 Hours**

Total: 60 Hours

Reference(s)

1. D.P Kothari, K. C Singal, Rakesh Ranjan, Renewable energy sources and emerging technologies, PHI Learning Pvt. Ltd 2013.
2. S.P Sukhatme, J.K Nayak, Solar Energy, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2014.
3. G.N. Tiwari, Solar Energy - Fundamentals Design, Modelling and applications, Narosa Publishing House, New Delhi, 2012.
4. Solanki, Solar Photovoltaics: Fundamental Technologies and Applications, Prentice-Hall of India Pvt.Limited, 3rd Edison, 2015.
5. Priscila Goncalves Vasconcelos Sampaio & Mario Orestes Aguirre Gonzalez, "Photovoltaic solar energy: Conceptual framework", Renewable and Sustainable Energy Reviews Volume 74, July 2017.

22EE607 MINI PROJECT II 0 0 2 1

Course Objectives

- Identify the problem statement and apply the engineering concepts to find the solution.
- Improve the analysing capability of the students.
- Increase the exuberance in finding the solution to various problems.

Course Outcomes (COs)

1. Formulate a real-world problem, identify the requirement, and develop the design solutions.
2. Identify technical ideas, strategies, and methodologies.
3. Utilize the new tools, algorithms, and techniques that contribute to obtaining the solution of the project.
4. Test and validate through conformance of the developed prototype and analysis of the cost-effectiveness.
5. Prepare the report and present oral demonstrations.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	1	2	1	1	2			2	2	2			2	2
2		-	1	1	2			2	2	2			2	2
3			1	1	2			2	2	2	2		2	2
4		-	1	1	2			2	2	2	2		2	2
5			-		2			2	2	2			2	2

Total : 30 Hours

22EE701 ELECTRIC VEHICLE TECHNOLOGY 3 0 0 3

Course Objectives

- To understand the drive train of electric vehicle and different types of electric vehicles
- To understand the operation of various motors used for propulsion in electric vehicles.
- To categorize battery storage technologies used in electric vehicle system.
- To understand the fuel cells for energy storage in electric vehicles.
- To explore the modelling method of an electric two wheelers.

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

d. PO4.Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

g. PO7.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

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Subsume the electric vehicle architecture and different types of electric vehicles.
2. Integrate the characteristics of various electrical drive system used for electric vehicles.
3. Assess the suitable battery technology and charging structure for an electric vehicle.
4. Interpolate the performance of fuel cell energy storage system for an electric vehicle.
5. Demonstrate the skill on modelling of an electric vehicle.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	1	1	3			3							
2	1	2	1										3	
3	1	3	2										2	
4	1	2	2										1	
5		3	3				2						3	3

B.E. - EEE / Minimum Credits to be earned: 163 / Regulations 2022

UNIT I **8 Hours**

INTRODUCTION

Importance and need of the electric vehicle(EV)- Comparative study on IC engine vehicles and electric vehicles-Overview of Electric Vehicle in India-Power train in electric vehicle: motors, controllers, battery, sensors-Types of EVs- Pure EVs, Plug-in EVs, Hybrid EVs, Plug-in Hybrid EVs, Fuel Cell EVs-Overview of Tesla Car.

UNIT II **9 Hours**

DRIVE SYSTEM FOR EVs

Configuration and control of Brushed and brushless DC Motor drives, Induction Motor drives, Permanent Magnet Motor drives, switched reluctance motor for EVs- Regenerative Braking in EVs-Drive system efficiency

UNIT III **10 Hours**

BATTERY TECHNOLOGY FOR EVs

Types of batteries-Characteristics of Electric vehicle Battery-Lead Acid battery-Lithium Ion battery -Ah rating-C-rate-Charging and discharging characteristics- Charger requirements-Types of charging methods-Battery Management System- EV charging standards, V2G, G2V, V2B, V2H.

UNIT IV **9 Hours**

FUEL CELLS FOR EVs

Fuel cell: Introduction, Technologies & Types, Obstacles- Operation principles, Potential and I-V curve, Fuel and Oxidation Consumption, Fuel cell Characteristics – Efficiency, Durability, Specific power, Power design of fuel Cell Vehicle and freeze capacity. Lifetime cost of Fuel cell Vehicle – System, Components, maintenance.

UNIT V **9 Hours**

ELECTRIC VEHICLE MODELLING

Tractive force of EV- Modelling Vehicle Acceleration: Electric Scooter Acceleration-Modelling EV Range: Driving cycles, Battery EV range modelling, Hybrid EV range modelling.

FOR FURTHER READING

Autonomous Electric Vehicle, Thermal Management in Battery Packs, Hacking of EV, Series, Parallel and Series-Parallel Hybrid EVs, Electric Car Modelling-Super Capacitors for EVs

Total: 45 Hours

Reference(s)

1. James Larminie, John Lowry, "Electric Vehicle Technology Explained", Wiley, 2012.
2. https://onlinecourses.nptel.ac.in/noc21_ee112/course.
3. Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay, Ali Emadi, “Modern Electric, Hybrid Electric, and FuelCellVehicles”, Taylor & Francis, CRC Press, 2018.
4. Akash Kumar Bhoi, Jens Bo Holm-Nielsen, Nil Patel, Sanjeevikumar Padmanaban,” Electric Vehicles:Modern Technologies and Trends”, Springer Nature Singapore, 2021.
5. Bruno Scrosati, Jurgen Garche, Werner Tillmetz, “Advances in Battery Technologies for ElectricVehicles”,Elsevier Science, 2015.

22EE702 INDUSTRIAL DRIVES AND AUTOMATION 3 0 2 4

Course Objectives

- To explore the various AC and special machine drives for industrial applications.
- To study the various open loop and closed loop control schemes for drives.
- To understand the fundamental concepts of industrial automation.
- To understand the communication protocols and ladder logic programming in PLC.
- To introduce the hardware implementation of the basic controllers using PLC.

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

e. PO5.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.

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Apply the various speed control techniques with converter topologies to control the AC drives.
2. Select the suitable special drives for open / closed loop control applications.
3. Apply the interfacing method to connect a suitable I/O device with PLC module for the given application.
4. Develop a PLC ladder program for open / closed loop control applications.
5. Apply the ladder logic principles to control the special drive for given application.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3												2	1
2	3	2											2	1
3	3	2			2								3	2
4	3		3										2	2
5	3		2		2								3	2

UNIT I **9 Hours**

AC DRIVES

Three phase induction motor – control methods – PWM inverter drives – VSI, CSI fed induction motor drives - Harmonic behavior - Rotor slip power recovery schemes. Synchronous motor – vector control – Open loop v/f control - load commutated Inverter control – VSI, CSI fed synchronous motor - Margin angle control and power factor control - Permanent magnet (PM) synchronous motor.

UNIT II **8 Hours**

SPECIAL DRIVES

Switched Reluctance Motor drive – Performance prediction – Control of SRM drive – Sensor less operation of SRM – Brushless DC motor drives - Variable reluctance and permanent magnet stepper motor Drives - Selection ofdrives and control schemes in industries - PLL, PID based control of drives –Closed loop control – sensor less BLDC motor control using PIC Controller.

UNIT III **9 Hours**

INDUSTRIAL AUTOMATION

Need and benefits of Industrial Automation, Automation Hierarchy, Basic components, Types. PLC Fundamentals - Building blocks, CPU, Memory organization, Input output modules (discrete and analog). Special I/0 Modules, Power supply, Fixed and Modular PLC – types, Redundancy, I/0 module selection, Interfacing different 1/0 devices with appropriate I/0 modules.

UNIT IV **9 Hours**

PLC BASED CONTROL

Bit logic instructions, interlocking, latching, inter dependency and logical functions, PLC Timer & Counterfunctions, Control components, sensors, actuators and valves, PID configuration, various network topologies and communication protocols like Profibus, Foundation field bus, Devicenet, HART.

UNIT V **10 Hours**

PLC PROGRAMMING AND APPLICATIONS

PLC I/0 addressing, programming Instructions – PLC programming language, Functional Block Diagram (FBD). Instruction List, Structured text, Sequential Function Chart (SFC), Ladder Programming, Ladder Logic for Automatic street light controller, Automatic agriculture irrigation system, Railway gate automation, Home automation, Bottle filling station.

LABORATORY EXPERIMENTS

EXPERIMENT 1

The students will be able to select the I/O ports and configure a PLC with HMI to develop a control structurefor an application.

10 Hours

EXPERIMENT 2

The students will be able to develop/execute a ladder program to sense and control various devices using PLCfor the given application.

10 Hours

EXPERIMENT 3

The students will be able to develop /test the ladder program in PLC for close loop control of the special drive and variable frequency drive.

10 Hours

Reference(s)

1. Vijay R Jadhav, Programmable Logic Controller, Khanna publishers, New Delhi, 3rd Edition, 2017.
2. John W Webb, Ronald A Reis, Programmable Logic Controllers, Principles and Applications, Pearson
Education, PHI, 5th Edition, 2016.
3. Mitra. Madhuchandra; Sengupta, Samarjit, Programmable logic controllers and Industrial automation, An
Introduction, Penram International Publication, New Delhi, 5th Reprint, 2015.
4. Haitham Abu-Rub, Atif Iqbal, Jaroslaw Guzinski, High Performance Control of AC Drives with Matlab / Simulink
Models, John Wiley & Sons Ltd, Publications, 2nd Edition, 2021.
5. R. Krishnan, Permanent Magnet Synchronous and Brushless DC Motor Drives, Taylor and Francis, CRC Press, 1st
Edition, 2017.

22EE707 PROJECT WORK I **0 0 4 2**

Course Objectives

- Work in teams to propose, formulate, and solve a challenging open-ended design problem of significant scope, depth, and breadth.
- Understand and incorporate engineering standards and multiple realistic constraints, within realistic design time, budget, and performance objectives.
- Develop a prototype of the proposed design and demonstrate the prototype in accordance with the specifications.
- Effectively communicate information relating to all aspects of the design process in written, oral, and graphical form.

Course Outcomes (COs)

1. Formulate a real world problem, identify the requirement and develop the design solutions.
2. Identify technical ideas, strategies and methodologies.
3. Utilize the new tools, algorithms, techniques that contribute to obtain the solution of the project.
4. Test and validate through conformance of the developed prototype and analysis the cost effectiveness.
5. Prepare report and present the oral demonstrations.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	2	3	3	1	3	3	3	3	3		2	3	3
2	2	2	3	3	1	3	3	3	3	3	-	2	3	3
3	2	2	3	3	3	3	3	3	3	3	3	2	3	3
4	2	2	3	3	3	3	3	3	3	3	3	2	3	3
5	2	2			2			3	3	3		2	3	3

Total: 60 Hours

22EE801 PROJECT WORK II **0 0 20 10**

Course Objectives

- Work in teams to propose, formulate, and solve a challenging open-ended design problem of significant scope, depth, and breadth.
- Understand and incorporate engineering standards and multiple realistic constraints, within realistic design time, budget, and performance objectives.
- Develop a prototype of the proposed design and demonstrate the prototype in accordance with the specifications.
- Effectively communicate information relating to all aspects of the design process in written, oral, and graphical form.

Course Outcomes (COs)

1. Formulate a real world problem, identify the requirement and develop the design solutions.
2. Identify technical ideas, strategies and methodologies.
3. Utilize the new tools, algorithms, techniques that contribute to obtain the solution of the project.
4. Test and validate through conformance of the developed prototype and analysis the cost effectiveness.
5. Prepare report and present the oral demonstrations.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	2	3	3	1	3	3	3	3	3		2	3	3
2	2	2	3	3	1	3	3	3	3	3		2	3	3
3	2	2	3	3	3	3	3	3	3	3	2	2	3	3
4	2	2	3	3	3	3	3	3	3	3	2	2	3	3
5	2	2			2			3	3	3		2	3	3

Total: 300 Hours

PROFESSIONAL ELECTIVES

VERTICAL I – POWER SYSTEMS

22EE001 POWER SYSTEM OPERATION AND CONTROL 3 0 0 3

Course Objectives

- Understand the application of load forecasting tools.
- Understand the real power-frequency relationship and the need for developing the mathematical model of Load Frequency Control Loop.
- Understand the reactive power-voltage relationship and the necessity of voltage compensation.

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineeringsciences

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

Course Outcomes (COs)

1. Apply the load forecasting tools to estimate the generation and reserve capacity
2. Apply the concept of Laplace transform to construct the transfer function model of isolated and interconnected systems.
3. Predict the transfer function model of excitation system and to classify system level voltage control methods
4. Apply the iterative techniques to determine economical operating point of generating units
5. Analyse the functions of load dispatch centers at National, Regional and State Levels.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	3											3	
2	3	3											3	
3	3	2											3	
4	3	3											3	
5	3	3											3	

UNIT I **9 Hours**

INTRODUCTION

System load variation: System load characteristics, load curves, Load-duration curve, load factor and diversity factor. Reserve requirements: Installed reserves, spinning reserves, cold reserves and hot reserves. Overview of system operation: Load forecasting, unit commitment and load dispatching. Overview of system control, Need for voltage and frequency regulation in power system, Plant level and System level controls.

UNIT II **10 Hours**

REAL POWER - FREQUENCY CONTROL

Fundamentals of speed governing mechanism and modeling: Speed-load characteristics-Load sharing between two synchronous machines in parallel; concept of control area, LFC control of a single-area system: Static and dynamic analysis. Multi-area systems: Two-area system modeling; static analysis; tie line with frequency bias control of two-area system. State variable model.

UNIT III **9 Hours**

REACTIVE POWER VOLTAGE CONTROL

Typical excitation system, modeling, static and dynamic analysis, stability compensation; generation and absorption of reactive power: Relation between voltage, power and reactive power at a node – method of voltage control - tap-changing transformer - System level control using generator voltage magnitude setting - tap setting of OLTC transformer and MVAR injection of switched capacitors to maintain acceptable voltage profile and to minimize transmission loss.

UNIT IV **9 Hours**

POWER SYSTEM ECONOMICS

Incremental cost curve, Unit Commitment and its constraints, Solution to unit commitment problem using priority list method- Economic Dispatch - co-ordination equations without loss and with loss, solution by direct method and lambda iteration method. (No derivation of loss coefficients.) Base point and participation factors. Economic dispatch controller added to LFC control.

UNIT V **8 Hours**

COMPUTER CONTROL OF POWER SYSTEMS

Energy control centre: Functions, Monitoring, data acquisition and control. System hardware configuration - SCADA and EMS functions: Network topology determination, security analysis and control. Various operating states: Normal, alert, emergency, in extremis and restorative. State transition diagram showing various state transitions and control strategies.

Total: 45 Hours

Reference(s)

1. Olle. I. Elgerd, “Electric Energy Systems Theory”, Tata McGraw Hill Publishing Company Ltd,New Delhi, Second Edition, 2017.
2. Allen.J.Wood and Bruce F.Wollenberg, “Power Generation, Operation and Control”, John Wiley & Sons Inc., New York 2013.
3. P.Kundur, Om P. Malik, “Power System Stability and Control”, Tata McGraw Hill Book Company, New Delhi,2022.
4. I.J. Nagarath, D.P. Kothari, “Modern Power System Analysis”, Tata McGraw Hill Publishing Company, New Delhi, 2022.
5. P. Venkatesh, B.V. Manikandan, S. Charles Raja, A. Srinivasan, “Electrical Power Systems Analysis, Security and Deregulation”, PHI Learning Private Limited, New Delhi, 2017

22EE002 POWER QUALITY **3 0 0 3**

Course Objectives

- To analysis the various power quality phenomenon, their origin and effects.
- To summarize the causes and impacts of various power quality issues.
- To understand the methods of power quality monitoring and standards.
- To analysis the performance of passive compensators for mitigating the power quality issues.
- To design the active compensators for load compensation.

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Analysis the different types of power quality problems like sag, swell, under voltage, overvoltage, inter harmonics and etc., with their source of generation.
2. Identify the various causes and impacts of power quality issues due to commercial, domestic and industrial loads.
3. Understand different methodologies for monitoring, detection and classification of power quality problems.
4. Analysis the behavioural performance of passive shunt and series filters for mitigating the power quality issues generated in power systems.
5. Design and analysis of FACTS controllers like distribution static compensator, dynamic voltage regulator and etc., for enhancing the quality of power.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO
1	2	3	3										2	2
2	2	3	3										2	2
3	3	2	2										2	2
4	2	3	3										2	3
5	2	2	3										2	2

UNIT I **9 Hours**

INTRODUCTION TO POWER QUALITY

Electric power quality phenomena. Classifications, characteristics and causes of short duration variation like sag, swell and interruption - Long duration variation like under voltage, over voltage and sustained interruption –

Transients, voltage imbalance, power frequency variations and waveform distortion like harmonics and DC offset.

UNIT II **9 Hours**

CAUSES AND IMPACTS OF POWER QUALITY ISSUES

Voltage sag due to faults, induction motor starting and transformer energizing. Over voltages due to capacitor switching, lightning and Ferro resonance. Harmonic sources from commercial and industrial loads. Classification and analysis of nonlinear loads. Effects of various power quality issues.

UNIT III **9 Hours**

POWER QUALITY MONITORING AND STANDARDS

Monitoring considerations. Power Quality Measurement - wiring and grounding test devices, disturbance analyzers,

Harmonic / spectrum analyzers and flicker meters. Smart power quality monitors, Expert system for power quality monitoring - IEEE and IEC standards.

UNIT IV **9 Hours**

PASSIVE COMPENSATION

Passive power filters - classifications, operations, design, modelling and performance analysis of passive shunt and series filters.

UNIT V **9 Hours**

ACTIVE COMPENSATION

FACTS devices: Classifications, operation, control methods, design and performance analysis of DSTATCOMs, DVRs and UPQCs.

FOR FURTHER READING

Estimation of voltage sag performance – Protection of overhead line, underground cables and transformers – Sag and harmonic indices – Harmonic distortion evaluation – Loads that causes the power quality problems.

Total: 45 Hours

Reference(s)

1. Roger. C. Dugan, Mark. F. McGranagham, Surya Santoso, H.Wayne Beaty, Electrical Power Systems Quality, McGraw Hill, 2017.
2. Bhim Singh, Ambrish Chandra, Kamal Al-Haddad, Power Quality: Problems and Mitigation Techniques, John Wiley & Sons, 2015
3. Heydt, G.T., Electric Power Quality, Stars in a Circle Publications, Indiana, 2nd edition 1996.
4. Arrillaga, J, Watson, N.R., Chen, S., Power System Quality Assessment, Wiley, New York, 2011.
5. M.H.J Bollen, Understanding Power Quality Problems: Voltage Sags and Interruptions, New York, IEEE Press, 2011

22EE003 HIGH VOLATGE TRANSMISSION 3 0 0 3

Course Objectives

- To understand the concept of HVAC and HVDC transmission systems
- To understand the concept of conductor and insulator design
- To explore the methods to convert high-voltage AC to high-voltage DC
- To predict the fault and provide proper protection to HVAC & HVDC transmission systems
- To classify the various filters used to mitigate the harmonics

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

d. PO4.Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Analyze the performance of HVAC system components.
2. Analyze the power transfer capabilities and power flow control in HVAC.
3. Analyze the characteristics of high voltage power converters in HVDC.
4. Apply suitable methods to measure and predict the faults in HVDC.
5. Analyze the harmonics mitigation technique using filters.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	2	2	2									2	2
2	2	2	2	2									3	2
3	2	2	2	2									2	2
4	2	2	2	2									2	2
5	2	2	2	2									2	2

UNIT I

HVAC CABLE DESIGN **9 Hours**

Design aspects of HVAC – conductor, tower, insulator and substation structure, design of EHVAC lines bas steady state limits and transient over voltages - design of extra HV cables - XLPE cables and gas insulated cable.

UNIT II

HVAC POWER FLOW CONTROL **9 Hours**

Real and reactive power flows in HVAC systems – reactive power compensation, short circuit level & real power transfer capacity. Stability- voltage stability and control. Theory of travelling and stationary waves.

UNIT III **9 Hours**

HVDC TRANSMISSION SYSTEM

Introduction to HVDC transmission - Bridge converters / rectifier and inverter operation/equivalent circuit representation, power reversal, desired features of control and actual control characteristics.

UNIT IV

9 Hours

HVDC PROTECTION AND CONTROL

Basic HVDC controllers, converter faults, commutation failure, bypass action in bridges, protection issues in HVDC - DC reactors, voltage and current oscillations, DC circuit breakers and over-voltage protection.

9 Hours

UNIT V

HARMONICS MITIGATION AND HYBRID HVDC

Harmonics in HVDC - characteristics and uncharacteristic harmonics, troubles due to harmonics, harmonic filters – active and passive filters. Introduction to Hybrid HVDC-Design aspects of Hybrid HVDC system.

Total: 45 Hours

Reference(s)

1. S.Rao, "EHV-AC, HVDC Transmission and Distribution Engineering", Khanna Publishers, 3rd Edition, 2018.
2. Rakosh Das Begamudre, "Extra High Voltage AC Transmission Engineering", New Age International Publishers, 3rd Edition, 2019.
3. Padiyar K.R., "HVDC Transmission Systems", New Age International Publishers, 2nd Revised Edition, 2018.
4. C.L. Wadhwa, "High Voltage Engineering", Wiley Eastern Limited, 2019.
5. E.Kuffel and M. Abdullah, "High Voltage Engineering", Pergamon Press, 2019.
6. Alston, "High Voltage Technology" BS Publications, 2017.

22EE004 DEMAND SIDE MANAGEMENT 3 0 0 3

Course Objectives

- To understand the energy scenario.
- To understand fundamentals of smart grid.
- To understand the concept of demand side management.
- To understand the economics of demand side management programs.
- To apply the cost effectiveness of demand side management.

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems
b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences
c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
d. PO4.Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions
m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.
n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Analyse the Energy Conservation Schemes through interpretation of energy audit results
2. Apply the concept of current and voltage flow to perform distribution load flow analysis.
3. Apply the concept of load forecasting to monitor the energy scenario.
4. Analyze the distribution system by performing demand side management
5. Analyze the economics effectiveness of demand side management.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2	2	2									2	2
2	3	2	2	2									2	2
3	3	2	2	2									2	2
4	3	2	2	2									2	2
5	3	3	3	3									2	3

UNIT I **9 Hours**

ENERGY SCENARIO

Energy Audit- Concept, Energy Index, Cost Index, Pie Charts, Sankey Diagrams, Load Profiles, Energy Conservation Schemes; Measurements in Energy Audits, Presentation of Energy Audit Results

UNIT II **9 Hours**

LOAD FLOW ANALYSIS

Radial Distribution Network - Distribution load flow – Load flow analysis of balanced radial distribution system - Load flow analysis of unbalanced radial distribution system - Load flow analysis of balanced weakly meshed distribution system

UNIT III **9 Hours**

LOAD FORECASTING

Power Loads, Connected Load - Load Forecasting; Regression Analysis, Correlation Theory - Factors in Power System Loading - Unloading the System - Forecast of System Peak, Strategic Forecasting, Spatial Load Forecasting - Scenario Planning - Sources of Error: Regulating the Model.

UNIT IV **9 Hours**

DEMAND SIDE MANAGEMENT

Demand Side Management – Concept, Techniques, Benefits; Time of Day Pricing, Multi-Utility Power Exchange Model, Time of Day Models for Planning; Load Management, Load Priority Technique, Peak Clipping, Peak Shifting, Valley Filling, Strategic Conservation, Energy Efficient Equipment. Management and Organization of Energy Conservation Awareness Programs

UNIT V **9 Hours**

ECONOMICS OF DSM

The time value of Money Concept, Cash flow model, Pay back analysis, Depreciation, Net present value calculations; Taxes and Tax Credit –Numerical Problems; Importance of evaluation, measurement and verification of demand side management programs

Total: 45 Hours

Reference(s)

1. A S. Pabla, Electric Power Distribution, Tata McGraw-Hill Education, 2019.
2. B. Das, Power Distribution Automation, IET Power and Energy Series, 75, London, 2016.
3. Albert Thumann, ‘Fundamentals of Energy Engineering’, CRC Press, 2015
4. W.R. Murphy & G. Mckay Butter worth, Energy management, Heinemann publications, 2003.
5. Ashok V. Desai, Energy Demand – Analysis, Management and Conservation, Wiley Eastern, 2005.

22EE005 SMART GRID TECHNOLOGIES 3 0 0 3

Course Objectives

- To summarize the components used in smart grid and technologies involved in smart grid.
- To understand the concept of smart metering and implementation of demand side integration.
- To analyze the concepts in automated distribution systems in smart grid.
- To analyze the concepts in automated transmission systems in smart grid.
- To analyze the significance of power electronics in smart grid.

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

e. PO5.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.

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

Course Outcomes (COs)

1. Examine the operating principles and models of Smart Grid components.
2. Classify the protocols of smart metering used in demand Side Integration.
3. Outline the distribution system automation in Smart Grid.
4. Outline the transmission system automation in Smart Grid.
5. Analyze the power quality improvement concepts in Smart Grid.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2				3								3	
2	2				3								3	
3	2				3								3	
4	2				3								3	
5	2				3								3	

UNIT I **9 Hours**

INTRODUCTION

Electrical Grid - Definition of Smart Grid - Opportunities, Challenges and Benefits of Smart Grid - Inventory of Smart Grid Technologies - Operating Principles and Models of Smart Grid Components, Implementation of Smart Grid- Early Smart Grid initiatives - Overview of the technologies required for the Smart Grid.

UNIT II **9 Hours**

SMART METERING AND DEMAND-SIDE INTEGRATION

Introduction - Smart metering - Smart meters- An overview of the hardware used-Communications infrastructure and protocols for smart metering, Demand-side integration- Services provided by DSI, Implementations of DSI, Hardware support to DSI implementations, Flexibility delivered by prosumers from the demand side, System support from DSI.

UNIT III **9 Hours**

DISTRIBUTION AUTOMATION

Distribution automation, automated meter reading (AMR), automated metering infrastructure (AMI), fault location isolation and service restoration (FLISR), Outage Management Systems (OMS), High Efficiency Distribution Transformers, Phase Shifting Transformers.

UNIT IV **9 Hours**

TRANSMISSION SYSTEM AUTOMATION

Substation automation, Feeder Automation, Supervisory control and data acquisition (SCADA), energy management system (EMS), phasor measurement units (PMU), Wide area monitoring systems (WAMS).

UNIT V **9 Hours**

POWER ELECTRONICS IN THE SMART GRID

Fault current limiting Shunt compensation, D-STATCOM, Active filtering, Shunt compensator with energy storage, FACTS- Reactive power compensation, Series compensation, Unified power flow controller.

FOR FURTHER READING

Smart appliance Technology - Pricing for Smart Appliances on demand. Security issues in DG, Distribution Automation, AMI, Electric Vehicle Management Systems - Approach to assessment of smart grid cyber security risks - Methodologies.

Total: 45 Hours

References:

1. Bimal K Bose, "Power electronics in renewable energy systems and smart grid: technology and applications", IEEE Press, 2019.
2. B. Vinoth Kumar, P. Sivakumar, M.M. Rajan Singaravel, K. Vijayakumar, "Intelligent Paradigms for Smart Grid and Renewable Energy Systems",Springer, 2021.
3. Omar Ellabban, Shady S Refaat, Sertac Bayhan, Haitham Abu-Rub, Frede Blaabjerg, Miroslav Begovic, " Smart
Grid and Enabling Technologies",Wiley - IEEE, 2021.
4. M. Kathiresh , A. Mahaboob Subahani , G. R. Kanagachidambaresan , "Integration of Renewable Energy Sources with Smart Grid", Wiley-Scrivener, 2021.
5. Ali Keyhani, " Design of smart power grid renewable energy systems", Wiley,2020.

22EE006 POWER SYSTEM DEREGULATION 3 0 0 3

Course Objectives

- To Understand the need for restructuring of Power Systems, different market models and market power.
- To Understand the market model, operations and challenges faced in a deregulation environment.
- To Understand the transmission open access and congestion management methods.
- To apply the concepts and terminologies in pricing methodology and available transfer capability.
- To Understand the reforms in the Indian Power Sector and for future expansion.

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

d. PO4.Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

e. PO5.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.

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Analyze the restructuring process, new entities in power market and benefits.
2. Explain the challenges faced in a deregulation environment with their market model and operations.
3. Analyze the transmission open access and congestion management methods.
4. Compute the pricing of power transactions and available transfer capability in a deregulation environment.
5. Elaborate the reforms in Indian Power Sector and in future.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2											3	
2	3	2		2									3	1
3	2			2	3								3	2
4	2				3								3	2
5	3	2		3									3	

UNIT I **9 Hours**

POWER SYSTEM DEREGULATION: AN OVERVIEW

Introduction- Motivation for Restructuring of Power System- Electricity Market Entities and Model- Milestones of Deregulation-International Scenario - Benefits of deregulation- Basic Terminologies.

UNIT II **9 Hours**

COMPETITIVE WHOLESALE ELECTRICITY MARKET

Introduction - Restructuring models - Role of Independent system operator - Power exchange (PX) - Market

Clearing Price (MCP) - Market operations - Whole sale electricity market characteristics - Challenges in wholesale electricity market.

UNIT III **9 Hours**

TRANSMISSION OPEN ACCESS

Introduction - Transmission open access- Types of Transmission services in open access - FERC order 889 - Structure of OASIS: Functionality and Architecture of OASIS - Congestion management - congestion management methods: An overview: Rescheduling of generation-Power World Simulation model.

UNIT IV **10 Hours**

PRICING AND AVAILABLE TRANSFER CAPABILITY

Introduction - Transmission cost components - Transmission pricing methods - Postage stamp method - contract path method-MW Mile method - Marginal participation method - Available Transfer Characteristics (ATC): Introduction -Definition - Methods of Static ATC Determination - Method based on multiple load flow and continuation power flow - method based on linear sensitivity factors - Power World Simulation model.

UNIT V **8 Hours**

INTERNATIONAL AND INDIAN POWER MARKET

Introduction - California Markets - New York Markets - PJM interconnection - Indian power sector past and present status-growth of power sector in India - overview - Time line of Indian power sector- Players in the Indian power sector.

FOR FURTHER READING

Electric Energy Trading, Electricity Price Forecasting, Demand Side Management

Reference(s)

1. M.Shahidepour, Hatim Tamin and Zuyi Li, "Market operations in electric power system forecasting,scheduling and risk management", John Wiley sons, 2002.
2. M.Shahidepour and M. Alomoush, "Restructured Electrical Power Systems: Operation: Trading, and Volatility", Marcel Dekker, Inc., 2001.
3. P.Venkatesh, B.V.Manikandan, S.Charles Raja and A.Srinivasan, "Electrical power systems analysis,Security and Deregulation", PHI 2012.
4. Loi Lei Lai, "Power system Restructuring and Deregulation" John Wiley sons, 2001.
5. Kankar Bhattacharya Maath H.J. Bollen and Jaap E.Daalder, "Operation of restructured power systems",Kluwer academic publishers, USA, first edition, 2001.

VERTICAL II POWER ELECTRONICS AND DRIVES

22EE007 ADVANCED POWER SEMICONDUCTOR DEVICES 3 0 0 3

Course Objectives

- To learn the characteristics of different types of semiconductor devices.
- To analyze the characteristics of power transistor
- To understand the construction and working principle of Thyristor
- To understand the operation and analyze the characteristics of power controlled devices
- To explore the need for isolation circuits and protection circuits

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Examine the performance characteristics of ideal and practical switches
2. Assess the performance characteristics of power transistor
3. Analyze the static and dynamic characteristics of thyristor
4. Analyze the static and switching characteristics of power controlled devices
5. Design a snubber and driver circuits for power controlled devices

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	1											3	
2	3	1											3	
3	3	1											3	1
4	3	1											2	1
5	2	1	3										3	2

UNIT I **9 Hours**

INTRODUCTION

Power switching devices -Attributes of an ideal switch, application requirements- circuit symbols - Power handling capability (SOA); Device selection strategy - On-state and switching losses - EMI due to switching - Power diodes - Types, forward and reverse characteristics, switching characteristics - Rating.Introduction to wide band gap semiconductors such as silicon carbide and gallium nitride.

UNIT II **9 Hours**

POWER TRANSISTOR

BJTs - Construction, static characteristics, switching characteristics - Negative temperature coefficient and Secondary breakdown - Power Darlington - Thermal protection-dynamic models of BJT

UNIT III **9 Hours**

THYRISTOR

Thyristors - working principle and its operating modes- Two transistor analogy- concept of latching - Gate and switching characteristics - Converter grade and inverter grade and other types; series and parallel Operation -Comparison of BJT and Thyristor- Steady state and dynamic models of BJT and Thyristor - thermal protection

UNIT IV **9 Hours**

POWER CONTROLLED DEVICES

Principle, construction, types of Power MOSFETs and IGBTs- static and switching characteristics -Steady state and dynamic models of MOSFET and IGBTs; Basics of GTO, MCT, and IGCT

UNIT V **9 Hours**

FIRING AND PROTECTING CIRCUITS

Necessity of isolation circuit- Pulse transformer- Opto-coupler; Gate drive circuit for SCR,MOSFET, IGBTs and base driving for power BJT - Overvoltage, over current and gate protections, Design of snubbers.

Total: 45 Hours

Reference(s)

1. Timothy L. Skvarenina, “The power electronics handbook”, CRC press, New Delhi, 2012.
2. M. H. Rashid, “Power Electronics circuits, Devices and Applications”, Prentice Hall of India, New Delhi, 2011.
3. Shen, Shyh-Chiang, “Wide-bandgap device research and development at SRL”, Georgia Instituteof Technology Semiconductor Research Laboratory, retrieved 2014-09-03.
4. Baliga, B. Jayant, “Fundamentals of Power Semiconductor Devices”, springer, 2008.
5. Ned Mohan, Undeland and Robins, “ Power Electronics Concepts, applications and design”, John Wiley and sons, Singapore, 2000.
6. D. Singh and K. B. Khanchandani, “Power Electronics”, Tata McGraw Hill book Co,New Delhi, 2003.

22EE008 ADVANCED POWER CONVERTERS

Course Objectives **3 0 0 3**

- To analyze the closed loop operation of switched mode power supplies.
- To understand the operation of switched mode rectifiers.
- To understand and analyze the various types of multilevel inverters.
- To evaluate the operation, and performance parameters of matrix converters .
- To understand the operation of soft switched power converters.

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems and designsystem components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

d. PO4.Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Apply the various converter topologies to design and analyze the switched mode power supplies.
2. Evaluate the input and output parameters of controlled rectifiers with PWM techniques.
3. Analyze the operation of advanced multilevel inverters with different modulation schemes.
4. Analyze the performance parameters of AC- AC converters with and without DC link.
5. Apply the soft switching techniques and analyze the performance of hard switched and soft switched converters.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2	2	3									2	2
2	3	2	2	3									3	2
3	3	2	2	3									3	2
4	3	2	2	3									3	2
5	3	2	2	3									3	2

UNIT I **9 Hours**

SWITCHED MODE POWER SUPPLIES (SMPS)

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

UNIT II **9 Hours**

AC-DC CONVERTERS

Switched mode AC-DC converters-synchronous rectification - single and three phase topologies - switching techniques - Power Factor: power factor improvement techniques- reduced input current harmonic distortion - with and without input-output isolation.

UNIT III **9 Hours**

DC-AC CONVERTERS

Multi-level Inverter-operation with equal and unequal DC voltages, - Inverters for open ended load configurations - Carrier modulation schemes of multilevel inverter, SVPWM of Multilevel inverter, Neutral Point Balancing schemes.

UNIT IV **9 Hours**

AC-AC CONVERTERS WITH AND WITHOUT DC LINK

Matrix Converters-Modulation techniques - scalar modulation, indirect modulation-Matrix converter as only AC- DC converter-AC-AC converter with DC link - topologies and operation - with and without resonance link - converter with dc link converter.

UNIT V **9 Hours**

SOFT-SWITCHING POWER CONVERTERS

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

Total: 45 Hours

FURTHER READING(s)

Dual active bridge, resonant inverters-High frequency magnetics-Emerging power semi-conductor devices.

Reference(s)

1. Muhammad H.Rashid, "Power Electronics Circuits, Devices & Applications", 4th Edition, Pearson India, 2018.
2. Ned Mohan, Tore. M. Undeland, William. P. Robbins, "Power Electronics: Converters, Applications and Design", 3rd Edition Wiley India, NewDelhi, 2012.
3. M.D.Singh & K.B Khanchandani, "Power Electronics", 2nd Edition, Tata Mc Graw Hill Publishing Co.Ltd., New Delhi, 2017.
4. Robert W.Erickson, Dragan Maksimovic, "Fundamentals of Power Electronics", Soringer Nature Switzerland AG 2020.
5. Marian P.Kazmierkowski, R.Krishnan and Frede Blaabjerg, "Control in Power Electronics- Selected Problem",Academic Press (Elsevier Science), 2002.
6. José Rodríguez, , Jih-Sheng Lai, and Fang Zheng Peng, "Multilevel Inverters: A Survey of Topologies, Controls, and Applications", IEEE Trans. Ind. Electron., Vol. 49, No. 4, August 2002.

22EE009 MODERN RECTIFIERS AND RESONANT CONVERTERS

3 0 0 3

Course Objectives

- To understand the importance of harmonics standards and operation of rectifiers in CCM & DCM.
- To analyze and design power factor correction rectifiers for UPS applications.
- To understand the source current shaping methods for rectifiers.
- To understand the resonant converters for SMPS applications.
- To analyze the performance of DC- DC Converters.

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

g. PO7.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

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Understand the types of modern rectifiers and its applications.
2. Analyze the performance of PWM inverters for specific applications.
3. Analyze the characteristics of resonant converters for different loads.
4. Apply the working linear system, state space model, PI controller.
5. Design a DC power supplies using advanced controller logic.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2	2				1						2	3
2	3	2	3										3	3
3	2	3	3										3	3
4	3	2	3										3	3
5	2	3	2				1						3	3

UNIT I **9 Hours**

LINE COMMUTATED RECTIFIERS

AC line current harmonic standards IEC1000-IEEE 519-CCM and DCM operation of single phase full wave rectifier- Behaviour of full wave rectifier for large and small values of capacitance - CCM and DCM operation of three phase full wave rectifier- 12 pulse converters- Multi Pulse converters - Harmonic trap filters

UNIT II **9 Hours**

PULSE WIDTH MODULATED RECTIFIERS

Properties of Ideal single phase rectifiers-Realization of nearly ideal rectifier-. Single-phase converter systems incorporating ideal rectifiers - Losses and efficiency in CCM high quality rectifiers -Single-phase PWM rectifier - device selection for rectifiers - Three phase PWM rectifier - applications of rectifiers

UNIT III **9 Hours**

DYNAMIC ANALYSIS OF SWITCHING CONVERTERS

Review of linear system analysis-State Space Averaging-Basic State Space Average Model State Space Averaged model for an ideal Buck Converter, ideal Boost Converter, ideal Buck Boost Converter and an ideal Cuk Converter. Pulse Width modulation - Voltage Mode PWM Scheme - Current Mode PWM Scheme - Design of PI controller.

UNIT IV **9 Hours**

RESONANT CONVERTERS

Soft Switching - classification of resonant converters - Quasi resonant converters- basics of ZVS and ZCS- half wave and full wave operation (qualitative treatment) - multi resonant converters - operation and analysis of ZVS and ZCS multi resonant converter - zero voltage transition PWM converters - zero current transition PWM converters

UNIT V **9 Hours**

SOURCE CURRENT SHAPING OF RECTIFIERS

Need for current shaping - power factor - functions of current shaper - input current shaping methods - passive shaping methods -input inductor filter - resonant input filter - active methods - boost rectifier employing peak current control - average current control - Hysteresis control Nonlinear carrier control.

FOR FURTHER READING

Zeta Converter, Push Pull converter, Space vector modulation

Total: 45 Hours

Reference(s)

1. Robert W Erickson and Dragon Maksimovic Fundamentals of Power Electronics Second Edition Springer science and Business media 2001.
2. William Shepherd and Li Zhang Power Converters Circuits Marceld Ekkerin C 2005.
3. Simon Ang and Alejandro Oliva Power Switching Converters Taylor and Francis Group 2010.
4. Andrzej M. Trzynadlowski Introduction To Modern Power Electronics John Wiley and Sons 2016.
5. Marian.K.Kazimierczuk and Dariusz Czarkowski Resonant Power Converters John Wiley and Sons limited 2011.
6. D. Grahame Holmes Thomas A. Lipo Pulse Width Modulation for Power Converters Principles and Practice Wiley IEEE Press 2003

22EE010 **ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY** **3 0 0 3**

Course Objectives

- Acquire knowledge on electromagnetic interference and electromagnetic compatibility.
- To understand the EMI and EMC standards
- To understand the EMI in electric circuits.
- To interpret the Noise suppression techniques.
- To select the appropriate EMI filtering methods.

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems
b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences
c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems anddesign system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
d. PO4.Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions
m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.
n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solvecomplex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Analyse the types and sources of EMI.
2. Apply the suitable measurement techniques and standards for EMI problems
3. Evaluate the EMI in electrical circuits
4. Apply appropriate techniques to control EMI .
5. Design a filter to suppress the EMI.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2	2	3									2	2
2	3	2	2	3									3	2
3	3	2	2	3									3	2
4	3	2	2	3									3	2
5	3	2	2	3									3	2

UNIT I **9 Hours**

INTRODUCTION

Sources of EMI- Inter systems and Intra systems EMI- Conducted and radiated interference- Characteristics -EMI predictions and modeling, - Methods of eliminating interferences- Design of electromagnetic compatibility (EMC)- EMC regulation typical noise path.

UNIT II **9 Hours**

EMI MEASUREMENT AND STANDARDS

EMI Measuring Instruments, Test Equipment, Measurement of Interference Voltage and Current- Spectrum Analysers - EMI Measurements for Consumer Appliances, Standards: Basic Standards, Product Standards, IEC, ANSI, FCC,CISPR, BSI,CENELEC, ACEC and MIL61E standards.

UNIT III **9 Hours**

EMI IN ELEMENTS AND CIRCUITS

Electromagnetic emissions, noise from relays and switches, non-linearity in circuits, passive intermodulation, transients in power supply lines, EMI from power electronic equipment, EMI as combination of radiation and conduction

UNIT IV **9 Hours**

NOISE SUPPRESSION TECHNIQUES

Noise Suppression in Relay Systems, Application of ACS switching Relays, Application of RC – Snubbers to Power Semiconductors, Shielded Transformers, Capacitor Filters, EMI Generation and Reduction at Its Source, Influence of Layout and Control of Parasitic.

UNIT V **9 Hours**

EMI FILTER CIRCUITS

Selection and Measurement, Test Methods, EMI Filter Design,-Insertion Loss, Design Method for Mismatched Impedance Condition, Design of EMI Filters with Common- Mode Choke Coils, Damped EMI Filters and Lossy Filter Elements.

Total: 45 Hours

Reference(s)

1. L. Tihanyi, "Electromagnetic compatibility in Power Electronics", IEEE press, 2020.
2. Bruce Archambeault, Colin Brench, Omar M. Ramahi, "EMI/EMC computational modelling handbook", Kluwer press, second edition, 2018.
3. D. Morgan, "A Handbook for EMC Testing and Measurement", IET Electrical Measurement Series, Band 8, 2018
4. Tim Williams, "EMC for product designers", Newnes press, fifth edition, 2016.
5. Henry W.Ott, “Noise reduction techniques in electronic systems”, John Wiley & Sons, 1989.
6. José Rodríguez, , Jih-Sheng Lai, and Fang Zheng Peng, ‘Multilevel Inverters: A Survey of Topologies, Controls, and Applications’, IEEE Trans. Ind. Electron., Vol. 49, No. 4, August 2015.

22EE011 ELECTRIC DRIVES AND CONTROL 3 0 0 3

Course Objectives

- To understand the motor, load dynamics, their nature and classification.
- To Apply power electronic converters to control the speed of DC motors.
- To analyze the speed control techniques for induction motor drives
- To analyze the performance of synchronous motor drives.
- To select the special electrical machines and control schemes for various industrial applications

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems
b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences
c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field ofElectrical and Electronics using contemporary tools.
n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Understand the dynamics of electrical drives, their nature and classification
2. Analyze the chopper fed DC drive.
3. Analyze the speed control techniques of induction motor drives
4. Analyze the performance of synchronous motor drives.
5. Select the special electrical machines and apply control schemes for various industrial applications

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	1	1										2	
2	3	3	1										2	1
3	3	3	1										2	1
4	3	1	1										2	
5	3	1	1										1	2

UNIT I 9 Hours

INTRODUCTION

Concepts, and classification of Electric drives. Selection of motors. Dynamics of Electric drives: Types of loads, Multi quadrant operations, motor dynamics steady state stability and transient stability. Rating and Heating of motors: Heating effects, heating and cooling curves, classes of duty, load equalization, environmental factors.

UNIT II **9 Hours**

DC MOTOR DRIVE

Basic characteristics, Operating modes, Single phase and three phase controlled rectifier fed DC drives, Dual converters drives, Chopper drives, Rheostatic and regenerative braking, effects of changes in supply voltage and load torque, closed loop control schemes.

UNIT III **9 Hours**

INDUCTION MOTOR DRIVES

Induction motor drives, stator voltage control, stator impedance control, rotor voltage control – Slip power recovery schemes, V/f control, Current control method. Need for harmonic filter, Closed loop control. Introduction to vector control scheme.

UNIT IV **9 Hours**

SYNCHRONOUS MOTOR DRIVES

Speed torque characteristics and torque angle characteristics. Fixed and variable frequency operation modes, Self-control modes.

UNIT V **9 Hours**

SPECIAL MACHINES

Brushless DC motor, Switched Reluctance Motor, introduction to the relevant converter circuits.

Total: 45 Hours

Reference(s)

1. G. K. Dubey, et.al., “Thyristorised Power Controllers,” New Age International, 2002.
2. Vedam Subramanyan, Electric Drives: Concepts and Applications, Tata McGraw Hill Publishing Company, New Delhi, 2011.
3. Krishan. R,'Permanent Magnet Synchronous and Brushless DC Motor Drives', CRC Press, 2010
4. Soumitra Kumar Mandal, Microprocessor & Microcontroller Architecture, Programming & Interfacing using 8085, 8086, 8051, McGraw Hill Education, 2013.
5. P. S. Bimbra Power Electronics, Khanna Publishers, third Edition, 2003.

22EE012 POWER ELECTRONIC INTERFACES FOR RENEWABLE ENERGY SOURCES

3 0 0 3

Course Objectives

- To analyse the current scenario of the implementation of renewable energy system.
- To understand the modern power converters for solar thermal systems.
- To understand the interfacing of power converters with wind energy systems
- To understand the operations of various generators used in WECS.
- To analyse the distributed power generation systems.

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Apply the rules and regulations for development of new energy technologies
2. Analyse the power converters for standalone solar power conversion system
3. Analyse the different configurations of wind energy conversion system
4. Analyze the converters for grid connected WECS and SECS
5. Apply the concepts of solar PV and wind energy conversion system to develop the distributed power generation system.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	2	2										2	3
2	2	2	2										2	2
3	2	2	2										2	2
4	2	2	2										2	2
5	2	2	2										2	2

UNIT I **9 Hours**

INTRODUCTION

Trends in energy consumption - World energy scenario - Energy sources and their availability - Conventional and renewable energy resources - Need to develop new energy technologies - Current status of renewable energy sources - Government Bodies and its function - MNRE & TEDA.

UNIT II **9 Hours**

SOLAR PV SYSTEMS

Solar radiation and measurements - Solar cells - Panels and their characteristics -Influence of insolation, temperature and parasitic capacitance PV arrays - power Converters-Maximum power point tracking - Applications.

UNIT III **9 Hours**

WIND ENERGY SYSTEMS

Principle of Wind Energy Conversion System- Nature of Wind - Components of Wind Energy Conversion System- Modern generators for WECS - Power conditioning schemes.

UNIT IV **9 Hours**

GRID CONNECTED WECS AND SECS

Grid codes- grid connectors -Grid related problems and standards-conventional and new grid synchronisation Methods-Generator control - Power converters for Grid connected WECS - Power converters for Grid connected SECS.

UNIT V **9 Hours**

DISTRIBUTED POWER GENERATION SYSTEMS

Hybrid Systems - Selection of power conversion ratio -Optimization of System components - Micro Hydro, wind, solar, and fuel cell systems - Converters and controllers for integration of renewable energy sources- types of energy storage systems

FOR FURTHER READING

Need for Hybrid Systems- Range and types of hybrid PV systems -SPV-Wind-Battery- fuel Cell-Diesel generator & grid interacted hybrid system - Micro hydro power - Co-generation

Total: 45 Hours

Reference(s)

1. S. Rao and Parulekar, Energy Technology Non Conventional, Renewable and Conventional, New Delhi, Khanna Publishers, 1999.
2. Rai G.D, Non conventional energy sources, Khanna Publishers, 1993.
3. Mukund R. Patel, Wind and Solar Power System, New York, CRC Press LLC, 1999.
4. Ned Mohan, Tore M. Undeland and William P.Robbins, Power Electronics: Converters, Applications and Design, New Jersey, John Wiley and Sons, 2003.
5. Remus Teodorescu, Marco Liserre, Pedro Rodriguez, Grid Converters for Photovoltaic and Wind Power Systems, John Wiley and Sons, Ltd., 2011.

VERTICAL III - ELECTRIC VEHICLE TECHNOLOGY

22EE013/22EEH01/22EEM01 ELECTRIC VEHICLE ARCHITECTURE 3 0 0 3

Course Objectives

- To understand the sizing and architecture of Electric vehicles.
- To apply the propulsion mechanics for Electric Vehicles.
- To analyse the power components and braking system for Electric Vehicles.
- To apply the various control strategies for Electric Vehicles.
- To apply the concepts of Plug-in Hybrid Electric Vehicle.

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems
b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences
c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems anddesign system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
d. PO4.Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions
m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.
n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solvecomplex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Illustrate the sizing of various components of Electric Vehicle.
2. Design a propulsion system for Electric Vehicle.
3. Analyse the power components and braking system for Electric Vehicles.
4. Apply the various control strategies for Electric Vehicles.
5. Implement the concept of plug-in hybrid electric vehicle.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	3	3	3									3	3
2	3	3	3	3									3	3
3	3	3	3	3									3	3
4	3	3	3	3									3	3
5	3	3	3	3									3	3

UNIT I

VEHICLE ARCHITECTURE AND SIZING **9 Hours**

Electric Vehicle History, and Evolution of Electric Vehicles - Series, Parallel and Series Parallel Architecture, Micro and Mild architectures - Mountain Bike - Motorcycle- Electric Cars and Heavy Duty EVs. -Details and Specifications.

UNIT II **9 Hours**

VEHICLE MECHANICS

Vehicle mechanics- Roadway fundamentals, Laws of motion, Vehicle Kinetics, Dynamics of vehicle motion, propulsion power, velocity and acceleration, Tire –Road mechanics, Propulsion System Design.

UNIT III **9 Hours**

POWER COMPONENTS AND BRAKES

Power train Component sizing- Gears, Clutches, Differential, Transmission and Vehicle Brakes. EV power train sizing, HEV Powertrain sizing, Example.

UNIT IV **9 Hours**

HYBRID VEHICLE CONTROL STRATEGY

Classification of control strategies: series, parallel, and power split-Different operating modes of hybrid vehicles: electric-only, engine-only, hybrid, regenerative braking-Control strategies for optimizing energy management and efficiency.

UNIT V **9 Hours**

PLUG-IN HYBRID ELECTRIC VEHICLE

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

Total: 45 Hours

Reference(s)

1. Mehrdad Ehsani, YiminGao, Sebastian E. Gay, Ali Emadi, 'Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design', CRC Press, 2004.
2. Build Your Own Electric Vehicle,Seth Leitman , Bob Brant, McGraw Hill, Third Edition 2013.
3. Advanced Electric Drive Vehicles, Ali Emadi, CRC Press, First edition 2017.
4. The Electric Vehicle Conversion Handbook: How to Convert Cars, Trucks, Motorcycles, and Bicycles -- Includes EV Components, Kits, and Project Vehicles Mark Warner, HP Books, 2011.
5. Heavy-duty Electric Vehicles from Concept to Reality, Shashank Arora, Alireza Tashakori Abkenar, Shantha Gamini Jayasinghe, Kari Tammi, Elsevier Science, 2021
6. Electric Vehicles Modern Technologies and Trends, Nil Patel, Akash Kumar Bhoi, Sanjeevikumar Padmanaban, Jens Bo Holm-Nielsen Springer, 2020

22EE014/22EEH02/22EEM02 DESIGN OF MOTOR AND POWER CONVERTERS FOR ELECTRIC VEHICLES **3 0 0 3**

Course Objectives

- To familiarize with power electronic components configuration to review the drive cycles and requirements of EVs
- To expose the utilization of different motors used in Electric Vehicle
- To learn the methods for analysing the behaviour of nonlinear control systems.
- To inculcate the knowledge to design and analyse power converters suitable for EV
- To design and analyse the transfer function of DC-DC converter used in EV

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems anddesign system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

d. PO4.Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

e. PO5.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.

h. PO8.Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice

j. PO10.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

l. PO12.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.

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solvecomplex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Explain the various parameters in dynamics of electric vehicles.
2. Apply controls of different motors for drive system efficiency.
3. Derive linear quadratic optimal controllers for scalar systems, and evaluate design parameters influence the closed-loop system properties.
4. Design and analyse closed loop Power converters for EV.
5. Analyse power electronics circuits and losses occurring in practice.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3		3					1		3		3	3	
2	3	3	3	3	3			1		3		3	3	3
3	3	3	3	3	3			1		3		3	3	3

4	3	3	3	3	3			1		3		3	3	3
5	3		3	3	3			1		3		3	3	3

UNIT I **9 Hours**

ELECTRIC VEHICLE DYNAMICS

Standard drive cycles-Dynamics of Electric Vehicles-Tractive force-Maximum speed, torque, power, energy requirements of EVs.

UNIT II **9 Hours**

MOTORS FOR ELECTRIC VEHICLES

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 **9 Hours**

BASICS OF SIMULATION IN CONTROL SYSTEMS

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 **9 Hours**

MODELING OF DC-DC CONVERTERS

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 **9 Hours**

POWER STAGE TRANSFER FUNCTIONS OF DC – DC CONVERTERS

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 Hours

Reference(s)

1. Power Electronic Converters, Teuvo Suntio, Tuomas Messo, Joonas Puukko, First Edition 2017.
2. Fundamentals of Power Electronics with MATLAB, Randall Shaffer, 2nd Edition, 2013, Lakshmi publications
3. Feedback Control problems using MATLAB and the Control system tool box, Dean Frederick and Joe Cho, 2000, 1st Edition, Cengage learning.
4. Handbook of Automotive Power Electronics and Motor Drives, Ali Emadi, Taylor & Francis, 2005,1st Edition.
5. Electrical Machine Fundamentals with Numerical Simulation using MATLAB/SIMULINK, Atif Iqbal, Shaikh Moinoddin, Bhimireddy Prathap Reddy, Wiley,2021, 1st Edition.
6. Emerging Power Converters for Renewable Energy and Electric Vehicles Modeling, Design, and Control, Md. Rabiul Islam,Md. Rakibuzzaman Shah, Mohd. Hasan Ali, CRC Press,2021, 1st Edition.

22EE015/22EEH03/22EEM03 ELECTRIC VEHICLE DESIGN, MECHANICS AND CONTROL

3 0 0 3

Course Objectives

- To understand the basics of EV and vehicle mechanics
- To identify the EV architecture and its types
- To find out the various types of energy storage system concepts
- To derive model for batteries and to know the different types of batteries and its charging methods
- To comprehend the control preliminaries for DC-DC converters.

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems
b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences
c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems anddesign system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
g. PO7.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
i. PO9.Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
j. PO10.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
l. PO12.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.
m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.
n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solvecomplex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Analyse the internal combustion engine based on vehicle fuel economy, emission control systems
2. Interpret the vehicle mechanics of EV and HEV
3. Analyse the battery pack and battery charging methods for different types of battery
4. Assess the stability of boost converter using bode plot
5. Evaluate the performance of AC motor with vector control and direct torque control.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	3							1	2		2	3	
2	3		3						1	3		2	3	
3	3	2					3		1	2		2	3	
4	3	3	2				3		1	2		2	3	

5	3	1					3		1	2		2	3	2

UNIT I **9 Hours**

INTERNAL COMBUSTION ENGINES

IC Engines, BMEP and BSFC, Vehicle Fuel Economy, Emission Control Systems, Treatment of Diesel Exhaust Emissions.

UNIT II **9 Hours**

ELECTRIC VEHICLES AND VEHICLE MECHANICS

Electric Vehicles (EV), Hybrid Electric Vehicles (HEV), Engine ratings- Comparisons of EV with internal combustion Engine vehicles- Fundamentals of vehicle mechanics.

UNIT III **9 Hours**

BATTERY MODELING, TYPES AND CHARGING

Batteries in Electric & Hybrid Vehicles – Battery Parameters. Types- Lead Acid Battery - Nickel-Cadmium & Nickel-Metal-Hydride (NiMH) Battery - Li-Ion & Li-Polymer Battery, Zinc-Air Battery, Sodium-Sulphur & Sodium-Metal-Chloride, R&D for Advanced Batteries. Battery- Modelling, Pack Management & Charging, Electric Circuit Models.

UNIT IV **9 Hours**

CONTROL PRELIMINARIES

Control Design Preliminaries - Transfer Functions – Bode plot analysis for First order and second order systems - Stability - Transient Performance- Power transfer function for boost converter - Gain margin and Phase margin study-open loop mode.

UNIT V **9 Hours**

CONTROL OF AC MACHINES

Introduction- Reference frame theory, basics-modeling of induction and synchronous machine in various frames-Vector control- Direct torque control.

Total: 45 Hours

Reference(s)

1. Electric and Hybrid Vehicles, Design Fundamentals, Third Edition, Iqbal Husain, CRC Press, 2021.
2. Power Electronic Converters,: Dynamics and Control in Conventional and Renewable Energy Applications, Teuvo Suntio, Tuomas Messo, Joonas Puukko, 1st Edition, Wiley - VCH.
3. Ali Emadi, Mehrdad Ehsani, John M.Miller, “Vehicular Electric Power Systems”, Special Indian Edition, Marcel dekker, Inc 2003, 1st Edition.
4. C.C. Chan and K.T. Chau, 'Modern Electric Vehicle Technology', OXFORD University Press, 2001, 1st Edition.
5. Wie Liu, “Hybrid Electric Vehicle System Modeling and Control”, Second Edition, John Wiley & Sons, 2017, 2nd Edition.
6. Dynamic Simulation of Electric Machinery using MATLAB, Chee Mun Ong, Prentice Hall,1997, 1st Edition.

22EE016/22EEH04/22EEM04 DESIGN OF ELECTRIC VEHICLE CHARGING SYSTEM

3 0 0 3

Course Objectives

- To understand the fundamental concept of charging stations and their standards.
- To learn about the working of power converters in electric vehicle charging stations.
- To find the various electric vehicle charging schemes using renewable energies and storage systems.
- To demonstrate the wireless power transfer technique for electric vehicle charging systems.
- To understand the necessity of PF improvement and design power factor correction circuits.

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems anddesign system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

d. PO4.Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

g. PO7.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

h. PO8.Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice

j. PO10.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

l. PO12.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.

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solvecomplex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Understand the various charging techniques, charging standards and regulations.
2. Analyze the working of DC-DC converters used in the EV charging systems.
3. Analyze the performance of renewable energy-based charging systems.
4. Evaluate the working principle of wireless power transfer in EV charging systems.
5. Evaluate the performance of power converters by boosting the power factor.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	3	3	3			2	2		3		3	3	-
2	3	3	3	3			2	2		3		3	3	3
3	3												3	3

4	3	3	3	3			2	2		2		1	3	3
5	3												3	3

UNIT I **9 Hours**

CHARGING STATIONS AND STANDARDS

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 **9 Hours**

POWER ELECTRONICS FOR EV CHARGING

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 **9 Hours**

EV CHARGING USING RENEWABLE AND STORAGE SYSTEMS

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 **9 Hours**

WIRELESS POWER TRANSFER

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 **9 Hours**

POWER FACTOR CORRECTION IN CHARGING SYSTEM

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.

Reference(s)

Total: 45 Hours

1. Mobile Electric Vehicles Online Charging and Discharging, Miao Wang Ran Zhang Xuemin (Sherman) Shen, Springer 2016, 1st Edition.
2. Alicia Triviño-Cabrera, José M. González-González, José A. Aguado, Wireless Power Transferor Electric Vehicles: Foundations and Design Approach, Springer Publisher 1st Edition. 2020.
3. Nil Patel, Akash Kumar Bhoi, Sanjeevikumar Padmanaban, Jens Bo Holm-Nielsen, Electric Vehicles Modern Technologies and Trends. Springer Publisher 1st Edition, 2021.
4. Cable Based and Wireless Charging Systems for Electric Vehicles, Technology and control, management and grid integration, Rajiv Singh, Sanjeevikumar Padmanaban, Sanjeet Dwivedi, Marta Molinas and Frede Blaabjerg, IET 2021, 1st Edition.
5. Electric and Hybrid Electric Vehicles, James D Halderman, Pearson, 2022, 1st Edition.
6. Handbook of Automotive Power Electronics and Motor Drives, Ali Emadi, Taylor & Francis, 2005.

22EE017/22EEH05/22EEM05 GRID INTEGRATION OF ELECTRIC VEHICLES

3 0 0 3

Course Objectives

- To understand the Vehicle-to-Grid (V2G) technology in the context of electric vehicle integration with the power grid.
- To understand the grid stability, energy efficiency, and economic advantages of V2G
- To identify and examine the challenges and barriers faced in the successful implementation of V2G.
- To Understand the impact of Electric Vehicles (EVs) and V2G technology on the smart grid and renewable energy systems.
- To comprehend the principles and strategies for effectively integrating and managing Electric Vehicles (EVs) within the existing power grid infrastructure.

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems
b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences
e. PO5.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.
g. PO7.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
h. PO8.Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice
j. PO10.Communication: Communicate effectively on complex engineering activities with theengineering 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
m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.
n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Assess V2G potential impact on the power grid and energy management.
2. Analyse the benefits of V2G integration, propose strategies for enhancing sustainable energy systems
3. Analyse the key challenges hindering V2G adoption, propose potential solutions for effective grid integration
4. Assess the influence of EVs and V2G on grid stability for optimizing their synergisticeffects.
5. Design and implement grid integration solutions of EVs while maintaining grid stability and efficiency.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3						2	1		2			3	3
2	3	3			3		2	1		2			3	
3	3						2	1		2			3	
4	3						2	1		2			3	
5	3						2	1		2			3	

UNIT I **9 Hours**

DEFINITION, And STATUS Of V2G

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

UNIT II **9 Hours**

BENEFITS OF V2G

Benefits of V2G, Technical Benefits: Storage Superiority and Grid Efficiency, Economic Benefits: EV Owners and Societal Savings, Environment and Health Benefits: Sustainabilityin Electricity and Transport, Other Benefits.

UNIT III **9 Hours**

CHALLENGES TO V2G

Battery Limitations and Vehicle Considerations- Policy and Regulatory Hurdles for V2G Adoption- Ensuring Data Security and Privacy in V2G- Overcoming User Resistance to V2G Participation- Planning for V2G Integration in the Power Grid- Assessing Environmental Impacts of V2G Deployment

UNIT IV **9 Hours**

IMPACT OF EV AND V2G ON THE SMART GRID AND RENEWABLE ENERGY SYSTEMS

EV Charging Infrastructure and Grid Integration - 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 **9 Hours**

GRID INTEGRATION AND MANAGEMENT OF EVS

Importance of Grid Integration - 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 Hours

Reference(s)

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 , Jesus Fraile- Ardanuy, " ICT for Electric Vehicle Integration with the Smart Grid", IET 2020, 1st Edition.
4. Junwei Lu and Jahangir, "Hossain Vehicle-to-Grid: Linking Electric Vehicles to the Smart Grid",IET 2015, 1st Edition.
5. Lance Noel · Gerardo Zarazua de Rubens Johannes Kester · Benjamin K. Sovacool, "Vehicle- to-Grid A Sociotechnical Transition Beyond Electric Mobility", 2019, 1st Edition.

22EE018/22EEH06/22EEM06 INTELLIGENT CONTROL OF ELECTRIC VEHICLES

3 0 0 3

Course Objectives

- To understand the mathematical model of a BLDC motor and its characteristics
- To understand the different control schemes for BLDC motor
- To understand the need of fuzzy in control of electric vehicles
- To understand the fundamentals of FPGA and VHDL
- To understand the fuzzy logic control of BLDC motor .

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems
b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences
c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.
n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Interpret the mathematical model of a BLDC motor and to discuss about its characteristics.
2. Represent the various speed control methods for controlling the speed of BLDC motor.
3. Infer the concept of fuzzy system
4. Understand the basics of VHDL & FPGA applied to control of EVs.
5. Design and implement of fuzzy logic control scheme for BLDC motor using FPGA in real time.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	1											1	1
2	1	2											1	1
3	2		2										3	1
4	2	1	2										3	1
5	2	1	3										2	1

UNIT I **9 Hours**

MATHEMATICAL MODEL AND CHARACTERISTICS ANALYSIS OF THE BLDC MOTOR

Structure and Drive Modes - Basic Structure, General Design Method, Drive Modes. Differential Equations, Transfer Functions, State-Space Equations., Starting Characteristics, Steady-State Operation, Dynamic Characteristics, Load Matching Commutation Transients

UNIT II **9 Hours**

SPEED CONTROL FOR ELECTRIC DRIVES

Introduction -PID Control Principle, Anti windup Controller, Intelligent Controller. Vector Control. Control applied to BLDC motor.

UNIT III **9 Hours**

FUZZY LOGIC

Membership functions, Fuzzification, Defuzzification, Fuzzy Arithmetic and Fuzzy Measures, Fuzzy Rule Base and Approximate Reasoning, Fuzzy Propositions, Rule Formation and Decomposition, Aggregation, Fuzzy Reasoning, Fuzzy Inference Systems, Fuzzy Expert System, Fuzzy Decision Making.

UNIT IV **9 Hours**

FPGA AND VHDL BASICS

Introduction – FPGA Architecture-Advantages-Review of FPGA family processors- Spartan 3, Spartan 6 and Spartan 7. VHDL Basics- Fundamentals-Instruction set-data type- conditional statements- programs like arithmetic, sorting, PWM generation, Speed detection.

UNIT V **9 Hours**

REAL TIME IMPLEMENTATION

Inverter design, identifying rotor position via hall effect sensors, open loop and fuzzy logic control of 48 V BLDC motor using FPGA.

Total: 45 Hours

Reference(s)

1. John G. Hayes, G. Abas Goodarzi, 'Electric Powertrain Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles' Wiley 1st Edition 2018.
2. Jayaram Bhasker, 'VHDL Primer', A (3rd Edition), Prentice Hall, 1st Edition 2015.
3. Iqbal Hussain, "Electric and Hybrid Vehicles: Design Fundamentals, Third Edition" CRC Press, Taylor & Francis Group, 2021, 1st Edition.
4. Chang-liang, Permanent Magnet Brushless DC Motor Drives and Controls, Xia Wiley 2012, 1st Edition.
5. M.N. Cirstea, A. Dinu, J.G. Khor, M. McCormick, Neural and Fuzzy Logic Control of Drives and Power Systems, Newnes publications, 1st Edition, 2002.
6. Wei Liu, 'Hybrid Electric Vehicle System Modelling and Control', Wiley 2017, 2nd Edition.

VERTICAL IV – GREEN ENERGY TECHNOLOGY

22EE019 SOLAR ENERGY CONVERSION SYSTEMS 3 0 0 3

Course Objectives

- To provide solar radiation and its measurement techniques
- To understand the overview of solar pv cell and its mathematical model.
- To attain a broad comprehension on solar photovoltaic standalone and grid connected system
- To understand the operations of solar thermal energy conversion system.
- To understand the applications of solar pv and solar thermal systems

Programme Outcomes (POs)

a. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
d. Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
e. 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.
m. PSO1: Design, analyze, and evaluate the performance of Electrical and Electronics systems using contemporary tools to provide effective solutions for real-world problems.
n. PSO2: Apply technology to make a significant contribution in terms of Electrical Engineering Innovations and ethically supporting the sustainable development of the society.

Course Outcomes (COs)

1. Apply the various instruments for measuring solar radiation.
2. Analyse the I-V characteristics of Solar PV System and conversion efficiency
3. Design a converter control topology for standalone and grid connected PV systems.
4. Analyse the different types of solar thermal energy collectors.
5. Apply a suitable Solar PV or thermal systems for various domestic and industrial applications.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	1											1	
2	2	2		3	1								3	
3	2	2	3	1	1								3	
4	2		2		1								2	
5	3		2		1									2

UNIT I **9 Hours**

SOLAR RADIATION AND MEASUREMENT

Electromagnetic spectrum-Solar angles-Sun path diagrams-Solar insolation- -Radiation absorption, scattering -Measurement of radiation-Pyranometer-Pyrheliometer-Sunshine recorder.

UNIT II **10 Hours**

SOLAR PV CELL

Formation of a PN – junction - Space charge and internal field - Quasi - Fermi levels - The Shockley diode equation - Structure of a solar cell - The solar cell equation - I-V characteristics - Fill factor - Crystalline silicon solar cells - Thin film solar cells - PV Cell Interconnection and Module Fabrication - PV Modules and arrays -Conditions for maximum power Transfer-Conversion efficiency- Basics of Load Estimation.

UNIT III **8 Hours**

STAND-ALONE AND GRID CONNECTED PV SYSTEMS

Grid interconnection standards- - Inverter control topologies for standalone and grid connected systems-Feasible operating region of inverter for grid connected system -Real time issues in grid connected systems- Maximum Power Point Tracking algorithms.

UNIT IV **9 Hours**

SOLAR THERMAL ENERGY CONVERSION

Solar thermal energy- Solar flat plate collector, solar evacuated tube collector -Pool and Air Collectors Construction -Function - Solar heating and cooling system - Real time issues in solar thermal systems- Comparison of solar thermal and Solar PV systems.

UNIT V **9 Hours**

APPLICATIONS OF SOLAR PV AND SOLAR THERMAL SYSTEMS

Solar PV power plant - Photovoltaic applications: battery charger, domestic lighting, street lighting, water pumping -Solar thermal electric power plant -solar thermal applications: heating, cooling, desalination, drying, cooking, Solar Ponds.

FOR FURTHER READING

Indian and International Energy Policies-Recent trends in solar thermal and Solar PV systems - Limitations of solar thermal and PV systems.

Total: 45 Hours

Reference(s)

1. CS Solanki, Solar Photovotaics,Fundamentals, Technologies and Applications, 3rd edition, PHI Learning Pvt. Ltd., 2015.
2. Martin A. Green, Solar Cells Operating Principles, Technology, and System Applications PrenticeHall, 2008.
3. H.P. Garg and J. Prakash., Solar Energy,Fundamentals & Applications, Tata McGraw Hill book Co, New Delhi, 2017.
4. S.P. Sukhatme, J.K. Nayak, Solar Energy-Principle of thermal storage and collection, Tata McGraw Hill book Co, 3rd edition New Delhi, 2011.
5. G.N.Tiwari, Solar Energy-Fundamentals, Design,Modeling and Applications,Narosha Publishing House Ltd.,2013.
6. Amine Allouhi et al. Up-to-date literature review on Solar PV systems: Technology progress, market status and R&D, Journal of Cleaner Production (2022)

22EE020 WIND POWER TECHNOLOGY 3 0 0 3

Course Objectives

- To understand the wind power scenario, characteristics and classifications of WECS.
- To learn the design and control principles of Wind turbine.
- To understand the concepts of fixed speed and variable speed, wind energy conversion systems.
- To understand the operations of various generators used in WECS.
- To analyze the grid integration issues.

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

g. PO7.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

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field ofElectrical and Electronics using contemporary tools.

n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Analyze the performance of WECS and select a suitable site.
2. Analyze the control mechanism for wind turbine.
3. Analyze the different types of generator for fixed speed wind turbine systems.
4. Apply the characteristics of generators for variable speed constant frequency systems.
5. Analyze the interconnection requirements of grid connected systems.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2	2				1						2	3
2	3	2	3										3	3
3	2	3	3										3	3
4	3	2	3										3	3
5	2	3	2				1						3	3

UNIT I **9 Hours**

INTRODUCTION

Wind source -Characteristics of Wind Energy-Wind Energy Conversion System (WECS) siting - Classification- Types of Towers -Components of WECS-WECS schemes-Power obtained from wind-simple momentum theory-Aerodynamics of Wind turbine- offshore Wind Turbine.

UNIT II **9 Hours**

WIND TURBINES

Terminologies-Types of Wind Power Plants-HAWT and VAWT -Power developed-Thrust-Efficiency-Rotor selection-Rotor design considerations-Tip speed ratio-Number of Blades-Blade profile-Power Regulation-yaw control-Pitch angle control- stall control-Schemes for maximum power extraction.

UNIT III **9 Hours**

FIXED SPEED SYSTEMS

Generating Systems- Constant speed constant frequency systems -Choice of Generators-Deciding factors-Synchronous Generator-Squirrel Cage Induction Generator- Model of Wind Speed- Model of wind turbine rotor - Drive Train model.

UNIT IV **9 Hours**

VARIABLE SPEED SYSTEMS

Need of variable speed systems-Power-wind speed characteristics-Variable speed constant frequency systems synchronous generator- DFIG- PMSG -Variable speed generators modelling - Variable speed variable frequency schemes.

UNIT V **9 Hours**

GRID CONNECTED SYSTEMS

Wind interconnection requirements, low-voltage ride through (LVRT), ramp rate limitations, and supply of ancillary services for frequency and voltage control, Harmonics and Power Quality-Wind Turbine as a Discrete Generator-Islanding.

FOR FURTHER READING

Hybrid Energy systems- wind - photovoltaic systems-wind- diesel hybrid systems-diesel generator and photovoltaic systems.

Total: 45 Hours

Reference(s)

1. Earnest Joshua, “Wind Power Technology”, PHI Learning, New Delhi, 2019, ISBN: 978-8120351660.
2. S.N.Bhadra, D.Kastha, S.Banerjee, “ Wind Electrical Systems”, Oxford University Press,2010.
3. Ion Boldea, “Variable speed generators”, Taylor & Francis group, 2015.
4. Ahmad Hemami, “Wind Power Technology”, Cengage Learning Series in Renewable Energy, 2012.
5. N. Jenkins, “Wind Energy Technology”, John Wiley & Sons,2021.
6. Siegfried Heier, “Grid Integration of WECS”, John Wiley & Sons Ltd, 2014.

22EE021 FUEL CELL SYSTEMS **3 0 0 3**

Course Objectives

- To Understand the principles of fuel cell technology
- To understand the concept of fuel cell system components
- To differentiate and apply the working of different fuels cells.
- To analyse fuel cell system design and integration.
- To analyse the applications of fuel cell systems.

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

d. PO4.Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Apply the concepts of fuel cell basic components.
2. Analyse the working of fuel cell under different parameter constraints.
3. Analyse the benefits of fuel cells applications.
4. Analyse the role of Safety and Environmental Considerations.
5. Design solutions for optimised fuel cell systems.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2	2	2										2
2	3	2	2	2										2
3	3	2	2	2										2
4	3	2	2	2										2
5	3	2	2	2										2

UNIT I **9 Hours**

INTRODUCTION

Types of fuel cells: proton exchange membrane (PEM), solid oxide (SOFC), molten carbonate(MCFC), and phosphoric acid (PAFC) fuel cells-Working principles of fuel cells-Electrochemical reactions in fuel cells-Advantages and challenges of fuel cell technology

UNIT II **9 Hours**

FUEL CELL COMPONENTS AND MATERIALS

Electrodes and catalysts: types, characteristics, and selection criteria-Membranes and electrolytes: properties and considerations-Bipolar plates and current collectors-Gas diffusion layers and flow fields-Materials selection for fuel cell components-Durability and performance considerations

UNIT III **9 Hours**

FUEL CELL SYSTEMS AND DESIGN

System configurations: standalone, grid-connected, and hybrid systems-Balance of plant (BOP) components: compressors, humidifiers, heat exchangers, pumps, and control systems-System efficiency and optimization strategies-System integration and control-Safety considerations in fuel cell system design

UNIT IV **9 Hours**

FUEL CELL APPLICATIONS

Transportation applications: automotive, buses, and trains-Portable and off-grid power applications-Residential and commercial stationary power generation-Industrial and remote power systems-Emerging applications and market trends

UNIT V **9 Hours**

FUEL CELL PERFORMANCE, TESTING, AND CHARACTERIZATION

Fuel cell performance metrics: voltage-current characteristics, power density, and efficiency- Testing methodologies and protocols-Diagnosis and troubleshooting of fuel cell systems- Performance modelling and simulation-Lifetime and degradation analysis

FOR FURTHER READING

Fuel Cell Materials, Fuel Cell Stack Design, Fuel Cell Electrochemistry - Fuel Cell Degradation and Durability

Total: 45 Hours

Reference(s)

1. Ryan O'Hayre, Suk-Won Cha, Whitney Colella, and Fritz B. Prinz, “Fuel Cell Fundamentals”, PHI Learning, New Delhi, 2016
2. James Larminie and Andrew Dicks, “ Fuel Cell Systems Explained”, Latest edition: 2003.
3. Nigel Sammes and Ruud van Berkel, “Fuel Cell Technology: Reaching Towards Commercialization"”, (Latest edition: 2006).
4. Matthew M. Mench and Kwang J. Kim, “Fuel Cell Engines”, (Latest edition: 2008).
5. Ludwig Jörissen and Detlef Stolten, “Fuel Cells: Principles, Design, and Analysis”, (Latest edition: 2013)

22EE022 RENEWABLE ENERGY SYSTEM INSTALLATIONS AND MAINTENANCE 3 0 0 3

Course Objectives

- To Understand the fundamental principles and components of solar energy systems
- To understand site assessment and design considerations
- To understand the electrical wiring and commissioning of solar energy systems
- To apply the concepts and methods for maintenance and troubleshooting
- To apply the principles and applications of off-grid and grid-tied solar energy systems.

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

g. PO7.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

n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Apply the fundamental principles and components of solar energy systems
2. Assess the Design and plan for the solar energy systems
3. Design, installation and commissioning solar energy systems.
4. Analyse performance and troubleshooting techniques of solar energy systems.
5. Analyse performance of an off grid and grid tied solar energy systems

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2	2				2							2
2	3	2	3				2							2
3	2	3	3				2							2
4	3	2	3				2							2
5	2	3	2				2							2

UNIT I **9 Hours**

INTRODUCTION

Overview of solar energy and its importance Basic principles of solar energy conversions - Types of solar energy systems: photovoltaic (PV) systems and solar thermal systems - Components of a solar energy system: solar panels, inverters, batteries, charge controllers

UNIT II **9 Hours**

DESIGNING SOLAR ENERGY SYSTEMS

Site assessment and analysis for solar energy systems - Load estimation and energy consumption analysis - Sizing of solar energy systems based on energy needs - Placement and orientation of solar panels for optimal performance - Electrical design considerations: wiring, grounding, and safety.

UNIT III **9 Hours**

SOLAR ENERGY SYSTEM INSTALLATION

Preparing the site for installation: permits, regulations, and safety measures - Mounting and securing solar panels - Electrical wiring and connections - Installation of inverters, batteries, charge controllers, and other system components - Testing and commissioning the solar energy system

UNIT IV **9 Hours**

MAINTENANCE AND TROUBLESHOOTING

Regular maintenance practices for solar energy systems - Cleaning and inspection of solar panels - Monitoring and performance analysis - Identifying and addressing common issues and troubleshooting techniques - Safety precautions during maintenance activities.

UNIT V **9 Hours**

OFF-GRID AND GRID-TIED SYSTEMS

Off-grid solar energy systems: design and installation considerations - Battery storage systems: types, sizing, and maintenance - Grid-tied solar energy systems: connecting to the electrical grid - Net metering and feed-in tariffs - Backup power options and emergency preparedness

FOR FURTHER READING

Photovoltaic systems- Solar PV Engineering and Installation- Solar Power Plant Design

Total: 45 Hours

Reference(s)

1. Muhammad H., “Photovoltaic Systems: Analysis and Design”, Year: 2018
2. Michael Boxwell, “Solar Electricity Handbook: A Simple, Practical Guide to Solar Energy”,2020
3. Sean White "Solar PV Engineering and Installation: Preparation for the NABCEP PV Installation Professional Certification",2015.
4. Chetan Singh Solanki "Solar Photovoltaic Technology and Systems: A Manual for Technicians, Trainers, and Engineers",2012
5. Majid Ghassemi & Robert Foster, "Solar Energy: Renewable Energy and the Environment",2018.

22EE023 ENERGY STORAGE SYSTEMS 3 0 0 3

Course Objectives

- Understand the significance of energy storage schemes.
- Understand the working of two types of mechanical energy storage systems
- Understand the concepts of various models of batteries
- Understand the performance of passive energy storage elements.
- Understand the principles of different methods of thermal energy storage schemes

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems
b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences
c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
g. PO7.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
m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.
n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Justify the significance of energy storage in current scenario.
2. Apply the concepts of mechanical energy in storage schemes
3. Compare the working methods of various electrochemical batteries.
4. Apply the principle of Electromagnetism for energy storage.
5. Analyze the various methods of thermal energy storage systems.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2	2				1						2	3
2	3	2	3										3	3
3	2	3	3										3	3
4	3	2	3										3	3
5	2	3	2				1						3	3

UNIT I **8 Hours**

MODES OF STORAGE

Need and importance of Energy storage, Periodic Storage, Modes of Storage: Thermo-chemical energy storage, Energy Storage in Organic Fuels, Hydrogen Storage, Bio Fuel Cell and Green Battery storage.

UNIT II **9 Hours**

MECHANICAL ENERGY STORAGE

Introduction - Potential Energy Storage - Energy Storage in Pressurized Gas - Pumped-Hydro Storage - Kinetic Energy in Mechanical Systems - Linear and Rotational Kinetic Energy - Internal Structural Energy Storage, Applications

UNIT III **10 Hours**

ELECTROCHEMICAL ENERGY STORAGE SYSTEMS

Fundamental concepts - Reaction Mechanisms in Electrochemical Cells - Practical Parameters, Equivalent Circuit, Types of batteries: Primary, Secondary, Lithium, Solid-state and molten solvent, lead acid, Nickel Cadmium Batteries; Zinc Manganese dioxide, Applications.

UNIT IV **9 Hours**

ELECTROMAGNETIC ENERGY STORAGE SYSTEMS

Superconducting Magnet Energy Storage (SMES) systems, Energy in a Material in a Magnetic Field, Superconductive Materials, Super capacitor: Electrochemical Double Layer Capacitor (EDLC): principle of working, structure, performance and applications

UNIT V **9 Hours**

THERMAL ENERGY STORAGE

Basic Principles - Benefits - Methods - Sensible Thermal Energy Storage (TES)- Latent TES - Cold TES - Seasonal TES - Thermal Energy Savings - Environmental Impacts - Applications.

FURTHER READING

Ocean wave energy - conversion, principle, power plants, tidal energy conversion, Scope and development

Total: 45 Hours

Reference(s)

1. S.R. Khalid, " Energy Storage Systems: Operation and Control", CRC Press, 1st Edition, 2020.
2. Bengt Sunden and Mohammad Reza Ghalambor, "Handbook of Energy Storage: Types, Technologies and Applications", Springer, 1st Edition, 2019.
3. Huggins, Robert A., Energy Storage: Fundamentals, Materials and Applications, Second Edition, Springer US, 2015.
4. Ibrahim Dincer,Mark A. Rosen, Thermal Energy Storage Systems and Applications, 2nd Edition, Wiley, 2011.
5. Ru-shiliu, Leizhang, Xueliang sun, Electrochemical technologies for energy storage and conversion, First, Wiley publications, 2012.

22EE024 GRID INTEGRATION OF RENEWABLE SOURCES 3 0 0 3

Course Objectives

- To understand the operation of grid interconnected renewable energy systems.
- To identify the grid integration issues.
- To understand the grid integration of PV system.
- To understand the grid integration of wind system.
- To understand the Integration of alternate sources of energy.

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

d. PO4.Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solvecomplex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Understand the challenges and opportunities for renewable generation in both large interconnected grid and micro grid settings.
2. Identify the requirements for grid interconnection and its impact with NCE sources.
3. Analysis the current techniques of PV interconnections with power system.
4. Analysis the current techniques of wind interconnections with power system.
5. Analysis the principles, power and limitations of complex power networks incorporating distributed generation and storage.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	2	2										2	2
2	2	2	2										2	2
3	2	2	2	2									2	2
4	2	2	2	2									2	2
5	2	2	2	2									2	2

UNIT I **9 Hours**

INTRODUCTION

Introduction to renewable energy systems, environmental aspects of electric energy conversion, impacts of renewable energy penetration to grid. Grid Codes in India and other countries. Basic power electronic converters for renewable energy integration to grid - Qualitative analysis - Grid Interactive Inverters-matrix converters.

UNIT II **9 Hours**

IMPACT OF GRID INTEGRATION

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

UNIT III **9 Hours**

GRID INTEGRATION OF PV SYSTEMS

Grid-Connected PV Power Systems - Inverter Control Algorithms - Synchronous Reference Frame–Based Current Controller - Digital PI-Based Current Controller - Adaptive Notch Filter-Based Grid Synchronization - Modeling, Simulation, and Hardware Implementation of Controllers

UNIT IV **9 Hours**

GRID INTEGRATION OF WIND SYSTEMS

Wind interconnection requirements, low-voltage ride through (LVRT), ramp rate limitations, and supply of ancillary services for frequency and voltage control, current practices and industry trends wind interconnection impact on steady-state and dynamic performance of the power system including modeling issue.

UNIT V **9 Hours**

INTEGRATION OF ALTERNATE SOURCES OF ENERGY

Introduction, principles of power injection: converting technologies, power flow; instantaneous active and reactive power control approach; integrating multiple renewable energy sources; DC link integration; AC link integration; HFAC link integration; islanding and interconnection

Total: 45 Hours

Reference(s)

1. Marco H. Balderas, 'Renewable Energy Grid Integration, Nova Science Publishers, New York, 2009.
2. Majid Jamil, M. Rizwan, D.P.Kothari, 'Grid integration of solar photovoltaic systems', CRC Press, NewYork, 2017.
3. B. Fox, D. Flynn L. Bryans, N. Jenkins, M. O Malley, R. Watson and D. Milborrow, 'Wind Power Integration connection and system operational aspect, 1st Edition, IET Power and Energy Series 50, 2007.
4. H. Siegfried and R. Waddington, "Grid integration of wind energy conversion systems" John Wiley and Sons Ltd., 2006.
5. Felix A. Farret and M. Godoy Simoes, 'Integration of Alternative sources of Energy', 1st Edition, IEEE Press – Wiley-Interscience publication, 2006.

VERTICAL V - EMBEDDED SYSTEM DESIGN

22EE025 ADVANCED PROCESSOR ARCHITECTURES 3 0 0 3

Course Objectives

- To introduce the concept of RISC and CISC microcontrollers.
- To analyze the principles of parallel processing.
- To understand the concept of shared memory architecture in multiprocessing.

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

e. PO5.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.

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solvecomplex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Indicate multiprocessor cache mapping techniques, cache coherence and memory consistency models.
2. Interpret the RISC processor and interface with PIC microcontroller and various peripherals.
3. Analyze 16bit microcontroller RL78 and design microcontroller based systems for a Real Time application.
4. Apply various types of pipelining methodologies.
5. Analyze the concept of parallel architecture and programming.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	3											1	
2	1	2	3		1								2	2
3	2	3			1								3	1
4	3	2												2
5	1	3												

UNIT I **9 Hours**

PROCESSORS AND MEMORY HIERARCHY

Advanced processor Technology, Super scalar and vector processor, Memory hierarchy technology, Virtual Memory Technology.

UNIT II **9 Hours**

RISC PROCESSOR

RISC Vs CISC, RISC properties and evolution, Advanced RISC microcontrollers, PIC18xx microcontroller family, Architecture, Instruction set, ROM, RAM, Timer programming Serial port programming, Interrupt programming, ADC and DAC interfacing, CCP module and programming.

UNIT III **9 Hours**

CISC PROCESSORS

RL78 16 BIT Microcontroller architecture, Addressing modes, On Chip memory, ADC, Interrupts, MAC unit, Barrel shifter, Internal and external clock generation, Memory CRC, On chip debug function and self programming.

UNIT IV **9 Hours**

PIPELINING AND SUPERSCALAR TECHNIQUES

Linear Pipeline, Nonlinear pipeline, Instruction pipeline, Arithmetic pipeline, Superscalar and super pipeline design, Parallel and scalable architectures, Multiprocessor and Multicomputer.

UNIT V **9 Hours**

PARALLEL ARCHITECTURE AND PROGRAMMING

Overview of parallelism, Basic concepts in parallel programming, Microprocessor design phases and trends, Categorizations of multicore architectures, Multicore parallel processing models, Parallelization of programs, Levels of parallelism: Instruction level parallelism and Data level parallelism.

Total: 45 Hours

Reference(s)

1. Hwang. K, Advanced computer Architecture, Parallelism, Scalability, Programmability, Tata McGraw Hill, 3rd Edition, 1993.
2. Alexander G, James M. Conard, Creating fast, Responsive and energy efficient Embedded systems using the Renesas RL78 microcontroller, Micrium press, USA, Reprinted by S.P Printers, 2011.
3. V.Rajaraman and C.Siva Ram Murthy, Parallel Computers Architecture and Programming, PHI, 2000.
4. Quinn, M.J., Designing Efficient Algorithms for Parallel Computers, McGraw - Hill, 2003.
5. Muhammad Ali Mazidi, Rolind D. Mckinlay and Danny Causey. PIC Microcontroller and Embedded Systems, Pearson Education, 2008.
6. Darryl Gove, Multicore Application Programming: for Windows, Linux, and Oracle Solari, Pearson Education Inc., 2011.

22EE26 COMMUNICATION PROTOCOLS AND STANDARDS

3 0 0 3

Course Objectives

- To analyze the components and need for communication in ECU
- To analyze the functions and frame format of CAN protocols
- To analyze the concept of LINBus, MODbus and Flex Ray protocols
- To analyze the functions of OBD communication in inter vehicle communication
- To understand the Autosar Standard and its architecture

Course Outcomes (COs)

1. Choose the suitable ECU components for different communication
2. Analyze the performance of CAN protocols
3. Analyze the performance of LINBus, MODbus and Flex Ray protocols
4. Illustrate the architecture of OBD communication
5. Illustrate the architecture of Autosar Standard

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	3	1	2	3								2	
2	2	3	2		2									3
3	2	3	2		2									3
4	2	2			1								2	
5	2	1		2	3								2	

UNIT I **9 Hours**

INTRODUCTION

Introduction to ECU Functions and Components , Need for Communication in ECU , Types of Communication Onboard Communication, Diagnostic Communication, Measurement and Calibration , Protocols and Comparison to ISO OSI, In Vehicle Cybersecurity Issues and Challenges

UNIT II **9 Hours**

CAN FUNDAMENTALS

Introduction to CAN , Electrical properties-CAN signaling and data rates,CAN data frame format, CAN controller block diagram and working,CAN driver configurations,Software for CAN controller interfacing-CAN development tools

UNIT III **9 Hours**

LINBUS, AND MODBUS, FLEX RAY

LIN bus , basics LIN bus protocol,master slave configuration , Basics of MODBUS , MODBUS protocol , MODBUS application , Flex ray and Automotive Ethernet Introduction and Usage, CAN vs Automotive Ethernet

UNIT IV **9 Hours**

HIGH-LEVEL COMMUNICATION PROTOCOLS

Onboard Communication J1939 ,Introduction , Key Characteristics , J1939 Standard and Layer Model , J1939 PGN and SPN , J1939 Transport Protocol , OBD II , OBD vs ISO OSI Layers , OBD Connectors , OBD Services , OBD Parameter ID (PIDs) , OBD Connectors

UNIT V **9 Hours**

AUTOSAR ARCHITECTURE

Introduction to Autosar Standard and Consortium , Need for Autosar Architecture , Virtual Function Bus , Layered Architecture Model, Microcontroller Abstraction Layer , ECU Abstraction Layer , Service layer , Autosar example

Total: 45 Hours

Reference(s)

1. Olaf Pfeiffer, Andrew Ayre and Christian Keydel, Embedded networking with CAN and CANopen, Copperhill Technologies Corporation, 2008
2. Reference: www.can cia.org
3. SGS-Thompson, Lin Application note AN1278, SGS Thompson Ltd. 2002
4. Modbus-IDA, MODBUS application protocol specification, ModbusIDA, 2006
5. Siemens, Profibus network manual, Simens manual, 2009
6. Xiu Ji, Profibus in practice: System Architecture and Design, CRC press, 2015

22EE027 EMBEDDED C PROGRAMMING 3 0 0 3

Course Objectives

- To expose the students to the fundamentals of C Programming
- To familiarize the students with data structures concepts
- To introduce the students basic Linux concepts
- To involve the students to familiarize with SHELL programming
- To implement the device drivers in LINUX environment

Course Outcomes (COs)

1. Understand the fundamentals of C and Data Structures
2. Understand the basics of LINUX and SHELL programming
3. Analyze the basic knowledge of Embedded Linux
4. Apply the concepts of Kernel Module Programming
5. Implement Device Drivers programs and hands on experience in using state-of-art hardware and software tools

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	3	2										1	
2	2	3	2		2								1	
3	2	3	2		2								1	
4	2	2	2		2								2	
5	2	1		3									3	

UNIT I **9 Hours**

C LANGUAGE AND DATA STRUCTURES OF KERNEL PROGRAMMING

Basic Concepts of C, Embedded C Vs C, Embedded Programming aspects with respect to firmware and OS Functions, Arrays, Pointers, Structures and Inputs/Outputs. Linked List, Singly Linked List, Doubly Linked List, Queues.

UNIT II **9 Hours**

LINUX AND SHELL PROGRAMMING

Command prompt, X windows basics, navigating file system, Finding Files, working with folders, Reading files, Text editing in Linux, Compression and archiving tools, Basic shell commands, File Management, I/O Handling, File Locking. Processes, Prioritizing and killing processes, Scheduling Commands, Pipes and redirection, Regular expression, Pattern Matching, Scripting using for, while, if and other commands.

UNIT III **9 Hours**

EMBEDDED LINUX

Linux Basics, Booting process, Make files using SD card reader to transfer program. Introduction to Linux system calls, API"s, device drivers, compiling and installing a device driver.

UNIT IV **9 Hours**

KERNEL MODULE PROGRAMMING

Compiling kernel, configuring kernel and compilation, Kernel code, Browsers, Static linking, Dynamic linking of modules, User space, Kernel space concepts, writing simple modules, Writing, Make files for modules.

UNIT V **9 Hours**

DEVICE DRIVER CONCEPTS

Driver concepts, Block and character driver distinction, Low level drivers, OS drivers etc, writing character drivers, Device major, minor number.

Total: 45 Hours

Reference(s)

1. Neil Mathew, Richard stones, Beginning Linux Programming, 2012 reprint, Wrox-Wiley Publishing, USA.
2. Eric Foster Johnson, John C. Welch, Micah Anderson, Beginning shell scripting, 2012, reprint, Wrox-Wiley Publishing, USA
3. Derek Molloy, Exploring BeagleBone: Tools and Techniques for Building with Embedded Linux, 2015, 1st Edition, Wiley Publications, USA

22EE028 REAL TIME OPERATING SYSTEMS 3 0 0 3

Course Objectives

- To expose the students to the fundamentals of interaction of OS with a computer and User computation.
- To teach the fundamental concepts of how process are created and controlled with OS.
- To study programming logic of modeling Process based on range of OS features.
- To compare types and Functionalities in commercial OS, application development using RTOS.
- To involve Discussions/ Practice/Exercise onto revising & familiarizing the concepts acquired.

Course Outcomes (COs)

1. Understand Operating System structures and types.
2. Analyze the operating systems tasks and its assess to the resources.
3. Analyze the scheduling, disciplining of various processes execution.
4. Demonstrate commercial RTOS Suite features to work on real time processes design.
5. Develop Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in RTOS and embedded automation design.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	2	2											2
2		2		2	2									2
3		2	2	3	2									2
4		2	2	3	2									2
5		2		2	2									2

UNIT I **9 Hours**

INTRODUCTION TO OPERATING SYSTEMS

Basic Principles, Operating System structures, Operating Systems functions, System Calls, Files, Processes, Design and Implementation of processes, Communication between processes, Introduction to Distributed operating system, Embedded operating systems.

UNIT II **9 Hours**

OVERVIEW OF RTOS

RTOS Task and Task state, Process Synchronization, Message queues, shared memory, Mail boxes, pipes, Critical section, Semaphores, mutex, priority inversion and ceiling, circular and swinging buffers.

UNIT III **9 Hours**

TASK MANAGEMENT AND RTOS SCHEDULING

Process and Threads, Process Control Block, Process Attributes, Interrupt processing, memory management, Priority based scheduling, Rate-Monotonic scheduling, Earliest Deadline first scheduling

UNIT IV **9 Hours**

REALTIME KERNEL

Principles, Kernel, Monolithic and Microkernel, Design issues, Polled Loop Systems, RTOS Porting to a Target, Comparison and Basic study of various RTOS like VX works Linux supportive RTOS.

UNIT V **9 Hours**

APPLICATION DEVELOPMENT

Discussions on Basics of Linux supportive RTOS, uCOS-C Executive for development of RTOS Application, Case study.

Total: 45 Hours

Reference(s)

1. Herma K., Real Time Systems, Design for distributed Embedded Applications, 2011, 2nd edition, Springer, USA
2. Tanenbaum, Andrew, Modern Operating Systems, 2015, 4th ed., Pearson Prentice Hall, USA.
3. Ivan CibrarioBertolotti, Politecnico di Torino and Gabriele Manduchi, Real-Time Embedded Systems: Open-Source Operating Systems Perspective, 2012, 1st ed., CRC Press, USA.
4. Lyla B. Das, Embedded Systems an Integrated Approach, 2012, 1st ed., Pearson Education, India.
5. Karim Yaghmour,Building Embedded Linux System,O reilly Pub,2003
6. MukeshSighal and N G Shi, Advanced Concepts in Operating System, McGraw Hill,2000

22EE029 EMBEDDED LINUX 3 0 0 3

Course Objectives

- To understand the concept of embedded linux and desktop linux
- To Configure Linux environment and Tool-Chain
- To Demonstrate Linux Booting Process and to configure Linux Kernels

Course Outcomes (COs)

1. Understand the concepts of embedded Linux development model.
2. Develop a Linux Board Support Package and storage for a hardware platform
3. Analyze the features and internal architecture of kernel and tool chain
4. Analyze the porting issues in Linux Environment.
5. Apply the various development tools to customize the embedded linux application.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	2	2	2									2	
2	3	2	3										2	
3	2	3	3										2	
4	2	3	3	3									2	
5	1	2	3	2									2	

UNIT I **9 Hours**

INTRODUCTION

History of Embedded Linux, Embedded Linux versus Desktop Linux, Embedded Linux Distributions, Architecture of Embedded Linux, Linux Kernel Architecture, Linux StartUp Sequence

UNIT II **9 Hours**

LINUX FUNDAMENTALS

Board Support Package: Inserting BSP in Kernel Build Procedure, Boot Loader Interface, Memory Map, Interrupt Management, PCI Subsystem
Embedded Storage: Flash Map, MTD : Memory Technology Device, MTD Architecture, MTD Block and Character devices, Optimizing Storage Space.

UNIT III **9 Hours**

ARCHITECTURE OF EMBEDDED LINUX

Kernel Architecture, Kernel Functional Overview, Commands in Linux, Configuring the Linux Environment, Tool-chain: Configuration and Cross-Compilation, Linux Bootloader & U-Boot, Embedded Linux Kernel, Building Root File System.

UNIT IV **9 Hours**

PORTING APPLICATIONS

Architectural Comparison, Application Porting Road Map, Programming with Pthreads, Operating System Porting Layer (OSPL), Kernel API Driver

UNIT V **9 Hours**

DEVELOPMENT TOOLS

Embedded development environment, GNU debugger, tracing & profiling tools, binary utilities, kernel debugging, debugging embedded Linux applications, porting Linux, Linux and real time, SDRAM interface

Total: 45 Hours

Reference(s)

1. Chris Simmonds "Mastering Embedded Linux Programming", Second Edition, PACKT Publications Limited. 3rd Edition, 2021.
2. Karim Yaghmour, Jon Masters, Gillad Ben Yossef, Philippe Gerum, "Building embedded Linux systems", O Reilly, 2008.
3. P Raghvan, Amol Lad, Sriram Neelakandan, "Embedded Linux System Design and Development", Auerbach Publications, 2019.
4. Christopher Hallinan, "Embedded Linux Primer: A Practical Real World Approach", Prentice Hall, 2nd Edition, 2010
5. Derek Molloy, "Exploring Beagle Bone: Tools and Techniques for Building with Embedded Linux", Wiley, 1st Edition, 2014.
6. Christopher Hallinan, "Embedded Linux Primer: A practical real world approach", Prentice Hall, 2007

22EE030 VIRTUAL INSTRUMENTATION IN EMBEDDED SYSTEMS

3 0 0 3

Course Objectives

- To develop graphical programming environment in Virtual Instrumentation
- To develop skills in data acquisition, instrumentation and control.
- To develop Virtual Instruments system for the Real-Time applications

Course Outcomes (COs)

1. Analyze the concepts of traditional instruments and virtual instruments
2. Understand the overview of modular programming and the structuring concepts in VI programming
3. Formulate the procedure to install DAQ in various OS and its interfacing methods
4. Develop virtual instrument using NI software and hardware
5. Analyse the performance of signal processing tool kits in virtual instrumentation

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	3	1	1									1	
2	3	3	2	2	2								1	
3	2	2	2	1										1
4	3	3	3	1	2								1	2
5	3	2	2	1	2								2	2

UNIT I **9 Hours**

INTRODUCTION

Virtual Instrumentation: Historical perspective, advantages, block diagram and architecture of a virtual instrument, Conventional Instruments versus Traditional Instruments, data-flow techniques, Editing Debugging and Running a Virtual Instrument- Graphical programming palettes and tools - Front panel objects.

UNIT II **9 Hours**

GRAPHICAL PROGRAMMING ENVIRONMENT IN VI

FOR Loops, WHILE loops, Shift Registers, CASE structure, formula nodes-Sequence structures-Arrays and Clusters- Array operations - Bundle, Unbundle - graphs and charts - string and file I/O - High level and Low level file I/Os - local and global variables - VIs and sub-Vis.

UNIT III **9 Hours**

DATA ACQUISITION

Introduction to data acquisition on PC, Sampling fundamentals, Input/output techniques and buses. Digital and Analog I/O function - Buffered I/O - counters and timers, Data acquisition interface requirements, Issues involved in selection of Data acquisition cards.

UNIT IV **9 Hours**

VI IN EMBEDDED SYSTEM

Laboratory Virtual Instrumentation and Engineering Workbench (LabVIEW) - NI Multisim - NI ELVIS III Hardware - MyDAQ: Measurements & datalogging - MyRIO: Embedded Monitoring & Control - 5G wireless communication: NI SDR Hardware bundle for RF & Wireless communication system design - PCI, PXI system controllers, Ethernet control of PXI.

UNIT V **9 Hours**

ANALYSIS TOOLS AND APPLICATIONS

Fourier transform - Power spectrum - Filtering tools - CRO emulation - Audio signal processing using Signal processing toolkit - Virtual instrumentation application in Biomedical, Process Control and Mechatronics.

Total: 45 Hours

Reference(s)

1. Gary Johnson, LabVIEW Graphical Programming, Second edition, McGraw Hill, Newyork, 1997.
2. Behzad Ehsani , Data Acquisition Using LabVIEW, Packt Publishing, 2016
3. Lisa K. wells & Jeffrey Travis, LabVIEW for everyone, Prentice Hall, New Jersey,1997.
4. Nitesh Pradhan CLAD Preparation Book, Blue Rose Publishers, 2020.
5. Kevin James, PC Interfacing and Data Acquisition: Techniques for Measurement, Instrumentation and Control, Newness, 2000.

VERTICAL VI - ELECTRICAL TECHNOLOGY
22EE031 UTILISATION OF ELECTRICAL ENERGY

3 0 0 3

Course Objectives

- To understand the definitions for illumination and types of lamps.
- To Maintain different types of electrical utilities and systems.
- To look over the Electric drives for traction.
- To understand the Electric drives for elevators.
- To analyze the tariff and power factor improvement for all types of supplies.

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

d. PO4.Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

g. PO7.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

k. PO11.Project Management and Finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to ones own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Analyze the functioning of different types of lamps, laws and fittings.
2. Analyze different electric heating methods and different welding equipment.
3. Analyze About different types of electric drives and elevators.
4. Apply the different electric traction systems and speed calculations.
5. Apply the tariffs for various schemes and analyze equipment for power factor improvement.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	3	3	2			2				1		3	2
2	3	3	3	2			2				1		3	1

3	3	3	3	2			3				1		3	3
4	3	3	3	2			3				1		3	3
5	3	3	2	2			1				1		2	1

UNIT I **9 Hours**

ILLUMINATION

Illumination terminologies, Laws of Illumination, Inverse square law and Lamberts cosine law, Various types of lamps, LED lamps, Various lighting schemes: features and application, Domestic and industrial lamp fittings, Electronic ballast.

UNIT II **9 Hours**

ELECTRIC HEATING AND WELDING SYSTEMS

Concept of electrical heating, classification of electric heating, Induction heating, Dielectric heating, Types of welding systems, Arc welding, Supply requirements; AC welding machines, welding transformer, safety precautions

UNIT III **9 Hours**

ELECTRIC DRIVES AND ELEVATORS

Electric Drives, Transmission of mechanical power, Bearing, Size and rating of motor, Definition of standard rating as per IS, Load cycles, Load Equalization, Braking, Elevators, Factors on which shape and size of car depends, Bombay Lift Act 1939. (Latest Amendment).

UNIT IV **9 Hours**

ELECTRIC TRACTION

Requirements of an ideal traction system, different types of traction system used in India, Traction mechanics, Traction motors, Definition of average and schedule speed, factors affecting schedule speed, Speed, time curve, Current collecting System: Pantographs.

UNIT V **9 Hours**

TARIFF AND POWER FACTOR IMPROVEMENT

Tariff: Desirable characteristics, types, Power factor, Power factor improvement using; static capacitor, most economical power factor, location of power factor improvement, Devices from consumer and electrical supply company point of view.

Total: 45 Hours

Reference Book(s)

1. Pratap H, “Art and Science of Utilization of Electrical Energy” ,Dhanpat Rai &Sons, New Delhi, 2017.
2. Gupta J B “Utilization of Electric Power and Electric Traction”, S. K. Kataria & Sons, New Delhi, 2016.
3. Garg “Utilization of Electric Power and Electric Traction”, G. C. Khanna Publishers, NewDelhi, 2016,
4. Upadhyay J, Mahendra S N, “Electric Traction”, Allied Publisher Ltd., New Delhi, Latest edition .
5. Dubey G, “Fundamentals of Electrical Drives”,G. K. Narosa Publishing House. New Delhi, Latest edition.
6. Mehta V K, “Principles of Power system, S.Chand, New Delhi, Latest edition

VERTICAL VI ELECTRICAL TECHNOLOGY

22EE032 INDUSTRIAL ELECTRONICS 3 0 0 3

Course Objectives

- To study about the physical phenomena of different types of sensors.
- To understand about the measuring principal of MEMS devices and technologies.
- To understand about the MEMS devices and technologies and applications.
- To study about the role of FPGA in industrial applications.

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineeringsciences

c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

d. PO4.Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Explain the various Fundamental physical phenomena of sensors.
2. Explain the various technological advancement of sensors.
3. Understand the fundamentals of MEMS technologies and its application in industrial devices.
4. Explain and analyse the types and working principles of micro sensors
5. Analyse the role of FPGA in reconfigurable systems.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO 2
1	2	2	2	2									1	2
2	2	3	2	2									2	2
3	2	3	2	2									2	2
4	2	2	3	2									1	2
5	2	2	2	3									2	2

UNIT I **9 Hours**

FUNDAMENTALS OF SENSORS AND TRANSDUCERS

Performance terminology, static and dynamic characteristics of transducers, classification of sensors and transducers, signal processing and signal conditioning. Operational amplifiers, filters, protection devices, analogto digital converter, digital to analog converter.

UNIT II **9 Hours**

ADVANCED SENSOR TECHNOLOGIES

Laser production, characteristics of lasers, types of laser sensors, bar code sensors, benefits of bar coding, transponder, RFID (Radio Frequency Identification), electro-magnetic identifier, optical encoders, colour sensors, sensing principles, colour theory, unit colour measurement, colour comparator, colour sensing algorithm, fuzzy logic colour sensor. fuzzy logic for opt-electronic colour sensor in manufacturing.

UNIT III **9 Hours**

MEMS TECHNOLOGIES AND APPLICATIONS

Introduction to Microsystems and microelectronics - Applications of micro system in automotive - bio medical - aerospace - telecommunication industries. Trimmer's scaling vector and scaling laws, Materials for MEMS-Deposition - Etching-Molding.

UNIT IV **9 Hours**

MICRO SENSORS

Microsensors - Types of micro sensors - Micro accelerometer, Pressure sensors and thermal sensors. Micro actuation techniques - piezoelectric crystals - Shape memory alloys - bimetallics - conductive polymers. Micro motors - micro grippers - Microfluidic devices - Micro pumps - micro valves - valve less micro pumps.

UNIT V **9 Hours**

FPGAS AND RECONFIGURABLE SYSTEMS

Introduction-advanced Hardware resources in FPGAs-Software tools for FPGAs-role of FPGAs in reconfigurable Systems-applications.

FOR FURTHER READING

Continuous time Signals-Time Domain analysis of Continuous time signals-Frequency Domain analysis of Continuous time signals-Signal Processors-Discrete time (Digital) Filters.

Total: 45 Hours

Reference(s)

1. Maloney, Timothy, "Modern Industrial Electronics", Upper Saddle River: Prentice Hall. 2015.
2. A.K.Sawhney and P.Sawhney, "A Course on Mechanical Measurement Instrumentation and Control", Dhanpat Rai and Co, New Delhi, 2017
3. Tai Ran Hsu, "MEMS and Micro Systems Design and Manufacture", Tata McGraw-Hill Publishing Company Ltd, New Delhi, 2008.
4. Rehg, James, A., Sartori, Glenn," Industrial Electronics", Upper Saddle River: Prentice Hall. 2016.
5. G.K.Mithal,"IndustrialElectronics",Khanna Publishers,Delhi, 2016.

22EE033 ILLUMINATION ENGINEERING 3 0 0 3

Course Objectives

- To impart basic knowledge on Illumination.
- To understand the types of sources and accessories used in lighting.
- To understand the measurement techniques of illumination and its parameters.
- To illustrate the design procedures applicable for interior lighting.
- To illustrate the design procedures applicable for exterior lighting.

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

l. PO12.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.

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Explain the basic concepts of lighting.
2. Select the lighting source and its control technique based on the requirement.
3. Analyse the various parameters of illumination and their measuring techniques.
4. Apply the lighting procedure for designing exterior environments.
5. Apply the lighting procedure for designing interior environments.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO 2
1	3												1	
2	3													3
3	2	3											1	
4	2		3										3	2
5	2		3										3	2

UNIT I **7 Hours**

INTRODUCTION

Light and Lighting, Basic Concepts and Units, Photometry and Measurement, Quantity and Quality of Lighting. Factors affecting lighting, artificial lighting, Lighting scheme.

UNIT II **8 Hours**

ACCESORIES

Light sources: Daylight, Incandescent, Electric Discharge, Fluorescent, Arc lamps, Lasers, Neon signs,Energy Efficiency, LED - LCD displays, Luminaries, Wiring, Switching, Control circuits.

UNIT III **10 Hours**

CALCULATION AND MEASUREMENT

Luminance measurement, Effect of voltage variation, Lighting calculations and characteristic curves, Solid angle, Inverse square and cosine laws, Illumination from point, line and surface sources, Photometry and Spectro - photometry, photocells.

UNIT IV **10 Hours**

INTERIOR LIGHTING

Lighting design procedure for Industrial, Residential, Office, Departmental stores, Indoor stadium, Theatres and Hospitals-Energy Efficient Lighting.

UNIT V **10 Hours**

EXTERIOR LIGHTING

Environment and glare, Lighting Design procedure for Flood, Street, Sport, Aviation and Transportlighting, Lighting for Displays and Signalling-Energy Efficient Lighting.

FURTHER READING

Special Features of Aesthetic Lighting : Monument and statue lighting, Auditorium lighting

Total: 45 Hours

Reference(s)

1. Joseph B. Murdoch, Illumination Engineering from Edicoan Lamp to the Laser, Vision Communications, Washington DC, USA, 1994
2. Jack L. Lindsey, Applied Illumination Engineering, Prentice Hall of India, New Delhi, 2008.
3. Marc Schiler, Simplified Design of Building Lighting, John Wiley and Sons, 1997.
4. IES Lighting Handbook, 1993.
5. D.C. Pritchard, Lighting, Routledge, 6th Edition, 2016

22EE034 ELECTRICAL SAFETY 3 0 0 3

Course Objectives

- To provide knowledge on basics of electrical fire and statutory requirements for electrical safety.
- To understand the causes of accidents due to electrical hazards.
- To know the various protection systems in Industries from electrical hazards.
- To know the importance of earthing.
- To distinguish the various hazardous zones and applicable fire proof electrical devices.

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

f. PO6.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

g. PO7.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

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Analyze the basic concepts in electrical circuit and hazards involved in it.
2. Analyze the electrical hazards in the workplace and its impacts.
3. Examine the operation of various protection systems from electrical hazards.
4. Analyze the various safety procedures involved in the industries.
5. Explore the different hazardous zones in Industries and their safety measures.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	2	2			2	1						2	1
2	2	2	2			1	2						1	2
3	2	2	2			2							2	1
4	2	2	2			2	1						1	
5	2	2	2										2	1

UNIT I **9 Hours**

CONCEPTS AND STATUTORY REQUIREMENTS

Review of Electrical concept - electrostatics, electro magnetism, stored energy - working principles of major electrical equipment - Indian electricity act and rules - statutory requirements from electrical inspectorate- international standards on electrical safety.

UNIT II **9 Hours**

ELECTRICAL HAZARDS

Primary and secondary hazards - Energy leakage - clearances and insulation - current surges - electrical causes of fire and explosion - national electrical safety code ANSI- Lightning hazards.

UNIT II **9 Hours**

PROTECTION SYSTEMS

Fuse, circuit breakers and types - protection against over voltage and under voltage - safe limits of amperage – safe distance from lines - overload and short circuit protection - earth fault protection. - system grounding - equipment grounding - earth leakage circuit breaker (ELCB) - ground fault circuit interrupter - electrical guards - Personal protective equipment.

UNIT IV **9 Hours**

SELECTION, INSTALLATION, OPERATION AND MAINTENANCE

Role of environment in selection - protection and interlock - discharge rod and earthing devices - safety in the use of portable tools - preventive maintenance.

UNIT V **9 Hours**

HAZARDOUS AREAS

Hazardous area classification and classification of electrical equipment for hazardous areas (IS, API and OSHA standards)- classification of equipment/enclosure for hazardous locations.

Total: 45 Hours

Reference(s)

1. Fordham Cooper, W., "Electrical Safety Engineering, Butterworth and Company", London, Third Edition,2013.
2. "Indian Electricity Act and Rules", Government of India.
3. "Power Engineers", Handbook of TNEB, Chennai, 2010.
4. "Accident prevention manual for industrial operations", N.S.C., Chicago, 1982.
5. John Cadick, P.E., Mary Capelli-Schellpfeffer, Dennis K. Neitzel, Al Winfield, "Electrical Safety Handbook",Fourth Edition, Tata Mcgraw Hill, 2014.

22EE035 ENERGY AUDITING AND MANAGEMENT 3 0 0 3

Course Objectives

- To understand the Indian energy scenario and international energy policies.
- To study the energy utilization of electrical systems.
- To analyse the energy audit techniques by using suitable tools and energy balance.
- To study the energy management features and audit procedure.
- To gain the knowledge on financial management in energy audit.

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

g. PO7.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

k. PO11.Project Management and Finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to ones own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

l. PO12.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.

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Analyze the importance of energy policies, energy conservation act features and energy security.
2. Apply the different energy conservation technique involved in electrical and electromechanical devices.
3. Apply the suitable energy audit technique using appropriate tools to improve the system efficiency with mass and energy balance concept.
4. Analyze the suitable energy audit technique, procedure and bench marking in energy audit.
5. Analyze the energy conservation opportunities and the various financial technique adopted in energy management.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	2	2				1				1	1	2	2
2	2	2	2								1	1	2	2
3	2	2	2								1	1	2	2
4	3	2	2								1	1	3	2
5	2	2	2				1				1	1	2	2

UNIT I **10 Hours**

ENERGY SCENARIO AND ENERGY POLICY

Role of energy in economic development and social transformation- Indian energy scenario- Energy statistics 2021-international energy policies-G20 and OPEC countries - Need for use of new and non-renewable Energy-Energy conservation act-2001 & its features - Energy Security.

UNIT II **8 Hours**

ELECTRICAL ENERGY UTILITY SYSTEM

Transmission and Distribution Losses-Transformer losses - Electricity Tariff- Load management and maximum demand control- Electric motor-losses in induction motor- efficiency calculation-factors affecting motor performance-power factor - energy efficient motors.

UNIT III **7 Hours**

ENERGY AUDIT INSTRUMENTS AND ENERGY BALANCE

Electrical measurements- Instruments used in energy audit: Wattmeter - flue gas analysers- PQ analyzers- infrared Thermography-Energy efficiency calculation in lighting, pump Applications-Material balance- energy balance - features

UNIT IV **10 Hours**

ENERGY MANAGEMENT AND AUDIT

Definition and objective of energy management - Principle of energy management - Key elements of energy management -Roles and responsibilities of energy manager - energy audit definition -types- Detailed energy audit procedure- understanding energy cost -Bench marking.

UNIT V **10 Hours**

EVALUATION OF SAVING OPPORTUNITIES AND FINANCIAL MANAGEMENT

Determination of cost saving -conservation opportunities - Estimating cost of implementation -Financial analysis techniques-plant energy audit report - Simple payback period, Return on investment, Net present value, Internal rate of return.

FOR FURTHER READING

Energy conservation and management -case studies - BEE rules and regulations.

Total: 45 Hours

REFERENCE(S)

1. Jose Golden Berg, Thomas Johansson, A K N Reddy, Robert Williams “Energy for a sustainable world”, WileyEastern, 1988.
2. BEE reference book 1/2/3/4
3. Albert Thumann,Terry Niehus “A Handbook of Energy Audits”, Ninth Edition, 2012.
4. Charles E Brown, “World Energy Resources”, Springer, 2012.

22EE036 PLC and SCADA **3 0 0 3**

Course Objectives

- To understand the architecture of PLC
- To understand the PLC programming using ladder logic and instructions
- To develop a real time models using PLC for required applications.
- To understand the architecture and types of SCADA
- To interface the PLC with SCADA

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems
b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences
c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
f. PO6.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
m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.
n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Understand the network and communication devices for interfacing computer with PLC.
2. Analyse the different programming languages used in PLC.
3. Create and execute a ladder logic for the particular industrial application.
4. Understand the architecture of SCADA and its types.
5. Apply the Supervisory Control and Data Acquisition for the particular industrial application.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2	2			-							2	1
2	2	3	3			-							2	2
3	2	2	3			3							2	3
4	3	3	2			-							2	2
5	2	3	2			3							2	3

UNIT I **8 Hours**

ARCHITECTURE OF PLC

Components of PLC - sink and source I/O cards - Processor - Memory: Types of memory, Input and Output modules: Discrete, Analog -Scan time of PLC -Interfacing computer and PLC: RS232, RS485, Ethernet - Selection criteria for PLC

UNIT II **10 Hours**

PLC PROGRAMMING

Programming languages - Ladder logic components: User, bit, branch and internal relay instruction -Boolean logic - Latching –Timers and Counters. Instructions in PLC: Program Control, Math, Data Manipulation – Sequencer, Shift register and Analog Instructions.

UNIT III **9 Hours**

APPLICATIONS OF PLC

Case Studies: Motor control- Bottle filling system - Pick and place robot - Car Parking - Traffic light control-Elevators - Pneumatic stamping system - alarm control system.

UNIT IV **8 Hours**

INTRODUCTION SCADA

Supervisory Control and Data Acquisition-Architecture/block diagram, Benefits of SCADA Types of SCADA- SCADA System Hardware -Remote terminal unit-Master terminal unit-Data Storage- Application area of SCADA.

UNIT V **10 Hours**

SCADA INTERFACING AND APPLICATIONS

Connection Diagram - Object Linking and Embedding for Process control architecture – Steps in creating SCADA- Steps for Linking SCADA Object with PLC using OPC- Concept of Tag, Applications of SCADA: On-off Control Lamp, Traffic Light Control– Elevator system – conveyor system

FOR FURTHER READING

Distributed control System

Total: 45 Hours

Reference(s)

1. F.D. Petruzella, “Programmable Logic Controllers”, Tata Mc-Graw Hill, Third edition, 2015
2. John W Webb and Ronald A Resis, “Programmable Logic Controller”, Prentice Hall of India Pvt. Ltd., New Delhi, 2013
3. Hackworth, John Hackworth, “Federic Programmable logic controllers”, Prentice Hall of India Pvt. Ltd., New Delhi, 2013
4. Katariya Sanjay B, **“**Industrial Automation Solutions for PLC, SCADA, Drive and Field Instruments”, Notion Press; 1st edition, 2020.
5. Bailey David, Wright Edwin, “Practical SCADA for Industry”, Elsevier Publication 2003.

22EE037 ARTIFICIAL INTELLIGENCE IN ELECTRICAL ENGINEERING

3 0 0 3

Course Objectives

- To understand the models of artificial neural networks.
- To understand the deep learning methodologies
- To understand the concept of fuzzy logic principles.
- To understand the Genetic Algorithm and Particle Swarm Optimization.
- To apply the machine learning and deep learning techniques for practical applications

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems
b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences
c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
d. PO4.Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions
m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field ofElectrical and Electronics using contemporary tools.
n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Analyze the various artificial neural network algorithms.
2. Analyze the different methodologies used in deep learning
3. Apply the concept of fuzzy logic in Electrical systems.
4. Analyze the Genetic and Particle Swarm Optimization algorithms.
5. Apply the various artificial intelligence techniques in electrical systems.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2	2	2									2	2
2	3	2	2	2									2	2
3	3	2	2	2									2	2
4	3	2	2	2									2	2
5	3	3	3	3									2	3

UNIT I **9 Hours**

ARTIFICIAL NEURAL NETWORK

Artificial neuron, activation function, supervised, unsupervised learning, Single layer perceptron – Limitation – Multi layer perceptron – Back Propagation Algorithm (BPA) – Recurrent Neural Network (RNN) – Adaptive Resonance Theory (ART) based network – Radial basis function network –Reinforcement learning.

UNIT II **9 Hours**

DEEP NEURAL NETWORKS

Convolutional Neural networks- LeNet- AlexNet – GoogLeNet – ResNet - Long Short-Term Memory-Gate Recurrent Unit- Deep Belief Network - Ensemble methods: Bagging, boosting, Evaluating and debugging learning algorithms

UNIT III **9 Hours**

FUZZY SET THEORY

Fuzzy Sets – Set-theoretic operations – Member Function Formulation and parameterization – Fuzzy Rules and Fuzzy Reasoning - Extension principle and Fuzzy Relations – Fuzzy If-Then Rules – Fuzzy Reasoning – Fuzzy Inference Systems – Mamdani Fuzzy Models-Sugeno Fuzzy Models – Tsukamoto Fuzzy Models – Input Space Partitioning and Fuzzy Modeling.

UNIT IV **9 Hours**

GENETIC ALGORITHM AND PARTICLE SWARM OPTIMIZATION

Genetic Algorithms-Genetic representations and selection mechanisms; Genetic operators- different types of crossover and mutation operators – Particle Swarm Optimization- Topologies – Control parameters-Multi Objective Optimization Algorithm.

UNIT V **9 Hours**

AI APPLICATIONS

Load forecasting - Fault Identification in transmission lines - Energy management in Micro Grid - Duty ratio optimization in power converters.

Total: 45 Hours

Reference(s)

1. Ethem Alpaydin, Introduction to Machine Learning, Fourth Edition,MIT Press, 2020.
2. Andrew Glassner, Deep Learning: From Basics to Practice , First Edition, The Imaginary Institute, Seattle, 2018.
3. H J Zimmermann, Fuzzy set theory and its application, Second Edition, Allied Publishers, 2014.
4. Xin-She Yang , Nature – Inspired Optimization Algorithms, Second Edition , Elsevier , 2020.
5. Gheisarnejad, Meysam, Hamed Farsizadeh, and Mohammad Hassan Khooban. "A novel nonlinear deep reinforcement learning controller for DC–DC power buck converters." IEEE Transactions on Industrial Electronics 68.8 (2020): 6849-6858.
6. Asbery, Chris, and Yuan Liao. "Fault identification on electrical transmission lines using artificial neural networks." Electric Power Components and Systems 49.13-14 (2022): 1118-1129.

22EE038 BIG DATA ANALYTICS FOR SMART GRID 3 0 0 3

Course Objectives

- To understand the fundamental concepts of big data analytics.
- To understand the fundamentals of various big data analytics techniques
- To apply concept of cloud computing techniques for smart grid.
- To apply the big data analytics for smart grid data management.
- To analyse the smart metering data set in the power system.

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems
b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences
c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
d. PO4.Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions
n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Apply the concepts of big data applications for smart grid.
2. Analyse the big data tools and its analysis techniques.
3. Analyse the benefits of cloud computing in smart grid technology.
4. Analyse the role of big data in smart grid data management system.
5. Design solutions for smart grid system using big data analytics.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	2	2	2										2
2	3	2	2	2										2
3	3	2	2	2										2
4	3	2	2	2										2
5	3	2	2	2										2

UNIT I 9 Hours

INTRODUCTION

Introduction to Big Data Analytics - Fundamental Mathematical Prerequisites, Big Data Era, General Security Challenges - Challenges of conventional systems - Modern data analytic tools. History of Hadoop, Apache Hadoop, Analysing Data with Unix tools, Analysing Data with Hadoop, Hadoop Streaming, Hadoop Echo System.

UNIT II **9 Hours**

DATA ANALYSIS

Regression modeling, Multivariate analysis, Bayesian modeling, inference and Bayesian networks, Support vector and kernel methods, Analysis of time series: linear systems analysis, nonlinear dynamics - Rule induction. Sampling and large sample tests, chi- square test, theory of estimation, linear and polynomial fitting by the methods, correlation of bivariate frequency distribution.

UNIT III **9 Hours**

CLOUD COMPUTING APPLICATIONS FOR SMART GRID

Cloud computing in smart grid, Cloud computing architecture, Demand Response - Geographical Load-Balancing - Dynamic Pricing - Virtual Power Plant - Advanced Metering Infrastructure - Cloud-Based Security and Privacy.

UNIT IV **9 Hours**

SMART GRID DATA MANAGEMENT AND APPLICATIONS

Pricing and energy forecasting in Demand Response, case study on Energy Forecast, Smart Meter Data Management -PHEVs: Internet of Vehicles - Smart Buildings.

UNIT V **9 Hours**

SMART GRID DESIGN AND DEPLOYMENT

Attack detection, current problem and techniques, Secure Data Learning Scheme, Logical Security Architecture, Smart Metering Data Set Analysis—A Case Study, Security Schemes for AMI Private Networks, Simulation Tools- Worldwide Initiatives - Use of data analytics for renewable energy integration and grid resilience

FOR FURTHER READING

Legal Protection of Personal Data in Smart Grid and Smart Metering Systems, Phases of smart grid system development cycle, Smart Grid Security and Privacy of Customer-Side Networks

Total: 45 Hours

Reference(s)

1. Smart Grid Technology: A Cloud Computing and Data Management Approach, S. Misra and S. Bera, Cambridge University Press, 2018, 1st Edition.
2. Smart Grid Communication Infrastructure: Big Data, Cloud Computing and Security, F. Ye, Y. Qian and R.Q. Hu, Wiley IEEE Press, 2018, 1st Edition.
3. Smart Grid: Fundamentals of Design and Analysis, James A. Momoh, Wiley India, 2015, 1st Edition.
4. Big Data and Analytics, Seema Acharya, Subhashini Chellapan,, Wiley, 2015.
5. Big data analytics in future power systems, Ahmed F. Zobaa, Trevor J. Bihl, 1st Edition, CRC press 2018.

22EE039 INDUSTRY 4.0 **3 0 0 3**

Course Objectives

- To expose the various stages of industrial revolutions.
- To introduce and familiarize the industry 4.0 and its physical structure and interconnectivity.
- To understand the different Automation Systems concepts for various sectors from the Industry 4.0 perspective.
- To outline the cloud computing and cyber security in the robotics industry.
- To understand the concepts VR systems, work and list the applications of VR.

Programme Outcomes (POs)

a. PO1.Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

b. PO2.Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

c. PO3.Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

d. PO4.Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

e. PO5.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.

i. PO9.Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Apply the concept of Industry 4.0 transformation in industries.
2. Analyse the various systems used in a manufacturing plant and their role in an Industry 4.0 world.
3. Apply the concept Understand the smartness in Smart Factories, Smart cities, smart products and smart Services.
4. Analyze the types of Cloud computing and cyber security in a networked industrial System.
5. Analyze the Virtual reality requirements in the industries .

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	2	2	3									3	3
2	2	2	2	3									3	3
3	2	2	2	3	2								2	2

4	2	2	2	3	3				2				2	2
5	2	2	2	3	3				2				2	2

UNIT I **9 Hours**

INTRODUCTION

Introduction, core idea of Industry 4.0, origin concept of industry 4.0, Industry 4.0 production system, current state of industry 4.0, Technologies, how is India preparing for Industry 4.0.

UNIT II **9 Hours**

A CONCEPTUAL FRAMEWORK

Main Concepts and Components of Industry 4.0, State of Art, Supportive Technologies, Proposed Framework for Industry 4.0, Obstacles and Framework Conditions for Industry 4.0.

UNIT III **9 Hours**

TECHNOLOGY ROADMAP

Proposed Framework for Technology Roadmap, Strategy Phase, New Product and Process Development Phase ,Case Study: Smart Manufacturing, Smart Devices and Products.

UNIT IV **9 Hours**

ADVANCES IN ROBOTICS

Recent Technological Components of Robots- Advanced Sensor Technologies, Internet of Robotic Things, Cloud Robotics, and Cognitive Architecture for Cyber-Physical Robotics, Industrial Robotic Applications- Manufacturing, Maintenance and Assembly.

UNIT V **9 Hours**

VIRTUAL REALITY

Key Elements of Virtual Reality Experience, Virtual Reality System, Interface to the Virtual World-Input & output-Visual, Aural & Haptic Displays, VR Hardware and Software Technology, Industrial Applications of VR.

Total: 45 Hours

Reference(s)

1. Alp Ustundag, Emre Cevikcan, "Industry 4.0: Managing the Digital Transformation", springer, 2017.
2. Lane Thames, Dirk Schaefe, "Cybersecurity for Industry 4.0: Analysis for Design and Manufacturing", springer, 2017.
3. Diego Galar Pascual, Pasquale Daponte, Uday Kumar, "Handbook of Industry 4.0 and SMART Systems", Taylor and Francis,2020.
4. Steven M. LaValle, "Virtual Reality", Cambridge University Press, 2016.
5. William R Sherman and Jeffrey D Will, Morgan Kaufmann, Alan B Craig, "Developing Virtual Reality Applications: Foundations of Effective Design", 2009.
2011.

ONE CREDIT COURSES

22EE0XA INTEGRATED CIRCUITS FOR POWER MANAGEMENT

1 0 0 1

Course Objectives

To provide an overview about the,

- Power architecture design strategies with the foundation of basic principles, key design factors·
- Design, implementation, improvements in the power management due to the advancements in the Integrated circuits.
- Hands-on design experience with a basic calculation tool and an available online circuit simulation tool

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
d. Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.
n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

1. Understand of the design, analysis, and applications of integrated circuits (ICs) that are specifically tailored for power management purposes.
2. Gain Knowledge on power management, including voltage regulation, current limiting, power conversion, and energy efficiency.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	1	2	2	2									2	3
2	1	2	2	2									2	3

Introduction **15 hours**

Boundary of coverage - Revision of fundamentals - Voltage, current, Power, Efficiency - Types of DC-DC Converters - Switching Regulators and Linear Regulators - Thermal Analysis and Power budget Estimation - Design Using Linear Regulators - Input Parameter Analysis - Output Parameter Analysis - Power dissipation Analysis - Design Calculation - Components Selection and Simulation - Design Using Switching Regulators - Input Parameter Analysis - Output Parameter Analysis - Power dissipation Analysis - Design Calculation - Components Selection and Simulation.

Total: 15 Hours

Reference(s)

1. Robert W. Erickson and Dragan Maksimovic (2001). Fundamentals of Power Electronics.
2. Mona M. Hella, Patrick Mercier (2017). Power Management Integrated Circuits.
3. Arman Vassighi, ManojSachdev(2010).Thermal and Power Management of Integrated Circuits.
4. Emre Salman, Eby G. Friedman (2012).High Performance Integrated Circuit Design

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22EE0XB VISIONARY AUTOMATION

1 0 0 1

Course Objectives

- To Understand the range of hardware and software offerings provided by National Instruments for data acquisition and vision applications.
- To Identify various vision components, including cameras, lenses, and lighting systems, and their roles within a vision system using DAQ.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

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

d. Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

e. Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

- Describe the key features, capabilities, and specifications of various National Instruments hardware components.
- Develop comprehensive applications that seamlessly combine data acquisition and vision functionalities, demonstrating proficiency in LabVIEW programming.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	1	1	2	3								2	3
2	1	2	2	2	3								2	3

Introduction to National Instruments Hardware and Software platforms – Types of Architectures in LabVIEW programming – Integration and Testing of Data Acquisition System – Types and Selection of Vision components – Camera – Lens – Integration and configuration of vision components – Development of Application using DAQ and Vision modules.

Total : 15 Hours

Reference(s)

1. Jennings, R. and De La Cueva, F., 2020. LabVIEW graphical programming. McGraw-Hill Education.
2. Bitter, R., Mohiuddin, T. and Nawrocki, M., 2017. LabVIEW: Advanced programming techniques. CRC press.
3. RiteshKanjee, 2018, Learn Computer Vision and Image Processing in LabVIEW.
4. Seong-Min, K., Young-Choon, L., & Lee, S.-C. SICE-ICASE , 1508-1512. Wyszecki, G., & Stiles, W. (1982). Color Science: Concepts and Methods Quantitative Data and Formulae. New York: John Wiley & Sons.

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22EE0XC SOLAR PV SYSTEM DESIGN AND IMPLEMENTATION

1 0 0 1

Course Objectives

- To analyze site feasibility, solar irradiance, shading analysis, and other factors influencing system design.
- To understand and configure solar arrays, select appropriate inverters and batteries, and integrate balance-of-system components for optimal system performance.
- To understand interconnection requirements, grid integration, and the importance of complying with electrical codes to ensure safe and compliant installations.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

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

d. Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

h.Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

- Design solar PV systems, demonstrating the ability to assess site conditions, size arrays, select appropriate components, and optimize system layouts for maximum energy production.
- Develop skills in identifying and addressing common challenges in solar PV system implementation, such as shading issues, inverter failures, and grid interconnection complications.

Articulation Matrix

CO No	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2

1	1	2	2										2	2
2	1	2	2	2				2					2	2

Solar energy and its importance, Solar PV System Components, Site Assessment and Design, Solar PV Array Design, Inverter Selection and Sizing, Battery Storage Systems, Electrical Safety and Codes, System Monitoring and Maintenance, Economic Analysis and Financial Considerations, Case Studies and Practical Exercises, Emerging Trends in Solar PV, Environmental and Sustainability Considerations.

Total : 15 Hours

Reference(s)

1. Dunlop, D. W. A, "Solar Photovoltaic System Applications: A Guidebook for Off-Grid Electrification", Springer, Ist Edition, 2019.
2. Roger A. Messenger and Jerry Ventre, "Photovoltaic Systems Engineering", CRC Press, 3rd Edition, 2017
3. Chetan Singh Solanki, "Solar Photovoltaic Technology and Systems: A Manual for Technicians, Trainers and Engineers" Academic Press, 2016 (2nd Edition).
4. Michael Boxwell, "Solar Electric Handbook: Photovoltaic Fundamentals and Applications", Greenstream Publishing. 2nd edition, 2016.

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22EE0XD LOW POWERED INDUSTRIAL EDGE AGENT

1 0 0 1

Course Objectives

- To Understand the software offerings provided by Espressif Systems for data acquisition and various applications in Low Power.
- Identify various supported components/HW, including basic electronic devices.
- Understand how to code for a problem statement in Espressif IDF.

Programme Outcomes (POs)

a. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

b. Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

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

d. Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

e. Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

m. PSO1: Design, analyze, and evaluate the performance of real-world problems in the field of Electrical and Electronics using contemporary tools.

n. PSO2: Apply knowledge skills and attitude to conduct experiments and interpret data to solve complex engineering problems in the power systems network, power electronics, electric drives and develop control strategies by considering economic and environmental constraints.

Course Outcomes (COs)

- Brief Understanding on Low power Espressif modules' usages in Industry, smart buildings, etc.
- Able to code for Edge Embedded modules on IDF-SDK.
- Basic understanding and approach to handle logical problem statements in Embedded Programming.

Articulation Matrix

CO No	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
1	1	2	2										2	2
2			2	2	1								2	2
3	2	2	2	2	1								2	2

Introduction on EspressifDevKit - About Espressif-IDF SDK - Real-Time examples, Usease - discussions - "Hello World" compilation with IDF environment - Interfacing - LED, Switches, Relays, Digital Sensor(s) - Timer, Delays, PWM - Real world Problem solving 1 - Real world Problem solving 2.

Total: 15 hours

Reference(s)

1. https://www.espressif.com/en/products/sdks/esp-idf
2. https://github.com/espressif/esp-iot-solution

Resource Person
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