You Choose, We Do It

St. JOSEPH'S COLLEGE OF ENGINEERING

(An Autonomous Institution)

St. Joseph's Group of Institutions

Jeppiaar Educational Trust

OMR, Chennai - 119.

FACULTY OF ELECTRICAL ENGINEERING

REGULATIONS – 2021
(CURRICULUM & SYLLABUS)

M.E. POWER ELECTRONICS AND DRIVES
(Choice Based Credit System–CBCS)

I–IV Semesters

Vision of the department

- To promote the Department of Electrical and Electronics Engineering as a pioneer in education and research by imparting quality education, creating and upgrading the academic facilities and inculcating professional values to the students to face the challenges in the dynamic global society.

Mission of the department

- To attain utmost qualities of teaching–learning process and provide a vibrant environment for the students to exhibit their fullest potential in the field of Electrical and Electronics Engineering.
- To improve research and development skills among students towards providing technical solutions with ethical values to meet social challenges.
- To develop the students to face the technological requirements of the industry with professional values and make them employable and to impart the spirit of entrepreneurship for their successful career.

Program Education Objectives (PEOs)

PEO1: Graduates of this program will have technical knowledge with the ability to design, develop and test power electronic converters and incorporate them in the control of electric drives in real time applications.

PEO2: Graduates of this program will be equipped skillfully to carry out academic and industrial research with cutting edge technologies thereby providing appropriate solutions with insightful innovations.

PEO3: Graduates of this program will show strong aptitude towards continuous learning and exhibit exemplary determination towards being a part of academia and exhibit higher order of ethical responsibility.

PEO4: Graduates of this program will show involvement and willingness in assuming responsibility in societal and environmental causes to promote sustainable growth in satisfying energy needs.

Program Specific Outcomes (PSOs)

PSO1: Understand and analyze the need for different modern power electronic converters and implement them for the operation of real time adjustable speed drives for flexible control.

PSO2: Contribute towards effective utilization of renewable energy sources by enabling the harness of maximum power with the help of power electronic conversion topologies.

PSO3: Design robust controllers for efficient energy storage and consumption by real time control of energy storage devices.

PSO4: Enhance knowledge by formulating and carrying out experiments to promote active research in the field of power electronics and drives, in order to improve the performance of electrical power systems.

Program Outcomes (POs)

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

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

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.

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.

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.

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.

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.

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

PO9 – Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

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.

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.

PO12 – Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change

PEO / PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PEO–1	*	*	*	*	*	*	*	*				*
PEO–2	*	*	*	*	*	*	*	*	*		*	*
PEO–3	*	*	*		*	*	*	*				*
PEO–4	*	*			*	*	*	*				

PO / POST GRADUATE SUBJECTS MAPPING
MAPPING – PG – M.E. POWER ELECTRONICS AND DRIVES

SEMESTER	NAME OF THE SUBJECT	a	b	c	d	e	f	g	h	i	j	k	l
SEM I	**THEORY**												
	Applied Mathematics for Electrical Engineers	*	*	*	*								
	Power semiconductor Devices	*	*			*	*						
	Analysis of Electrical Machines	*	*	*	*	*	*						
	Analysis and Design of Power Converters	*	*	*		*	*						
	System Theory	*	*		*	*	*						
	Research Methodology and IPR				*	*	*		*	*	*	*	*
	Audit Course												
	PRACTICALS												
	Power Electronics Circuit Simulation Laboratory	*	*			*				*			
	Power Converters Laboratory	*	*			*				*			
SEM II	**THEORY**												
	Analysis and Design of Inverters	*	*	*	*	*	*						
	Analysis of Electrical Drives	*	*			*	*						
	Electric Vehicles and power management	*	*	*		*	*						
	Embedded Controllers	*	*	*	*	*	*						
	Professional Elective I												
	Professional Elective II												
	PRACTICALS												
	Embedded Controllers Laboratory	*			*	*				*			
	Mini Project	*					*		*	*	*	*	*
SEM III	**THEORY**												
	Professional Elective III												
	Professional Elective IV												
	Open Elective												
	PRACTICALS												
	Electrical Drives Laboratory	*	*			*				*			
	Project Work – Phase I	*	*	*	*	*	*	*	*	*	*	*	*
SEM IV	Project Work – Phase II	*	*	*	*	*	*	*	*	*	*	*	*

M.E. POWER ELECTRONICS AND DRIVES
REGULATIONS – 2020
CHOICE BASED CREDIT SYSTEM
I TO IV SEMESTERS CURRICULA & SYLLABI

SEMESTER – I

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	MA1153	Applied Mathematics for Electrical Engineers	FC	4	4	0	0	4
2.	PE1101	Power Semiconductor Devices	PCC	3	3	0	0	3
3.	PE1102	Analysis of Electrical Machines	PCC	3	3	0	0	3
4.	PE1103	Analysis and Design of Power Converters	PCC	3	3	0	0	3
5.	PE1104	System Theory	PCC	4	3	1	0	4
6.	RM1101	Research Methodology and IPR	RMC	2	2	0	0	2
Audit course (One from the list of Audit Course)			AC					
PRACTICALS								
7.	PE1111	Power Electronics Circuit Simulation Laboratory	PCC	4	0	0	4	2
8.	PE1112	Power Converters Laboratory	PCC	4	0	0	4	2
			TOTAL	**27**	**18**	**1**	**8**	**23**

SEMESTER – II

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	PE1201	Analysis and Design of Inverters	PCC	3	3	0	0	3
2.	PE1202	Analysis of Electrical Drives	PCC	4	3	1	0	4
3.	PE1203	Electric Vehicle and Power Management	PCC	3	3	0	0	3
4.	PE1204	Embedded Controllers	PCC	3	3	0	0	3
5.		Professional Elective I	PEC	3	3	0	0	3
6.		Professional Elective II	PEC	3	3	0	0	3
PRACTICALS								
7.	PE1211	Embedded Controllers Laboratory	PCC	4	0	0	4	2
8.	PE1212	Mini Project	EEC	4	0	0	4	2
			TOTAL	**27**	**18**	**1**	**8**	**23**

SEMESTER – III

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.		Professional Elective III	PEC	3	3	0	0	3
2.		Professional Elective IV	PEC	3	3	0	0	3
3.		Open Elective (One from list of 6 courses)	OEC	3	3	0	0	3
PRACTICALS								
4	PE1311	Electrical Drives Laboratory	PCC	4	0	0	4	2
5.	PE1312	Project Work – Phase I	EEC	12	0	0	12	6
			TOTAL	**25**	**9**	**0**	**16**	**17**
	Career Competency Development I – BEC Training			**1 WEEK**				

SEMESTER – IV

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
PRACTICALS								
1.	PE1411	Project Work – Phase II	EEC	24	0	0	24	12
			TOTAL	**24**	**0**	**0**	**24**	**12**

TOTAL NO. OF CREDITS: 75

CATEGORIZATION OF COURSES

FOUNDATION COURSES (FC)

SI. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	MA1153	Applied Mathematics for Electrical Engineers	FC	4	4	0	0	4

RESEARCH METHODOLOGY AND IPR COURSES (RMC)

SI. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	RM1101	Research Methodology and IPR	RMC	2	2	0	0	2

PROFESSIONAL CORE COURSE (PCC)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	PE1101	Power Semiconductor Devices	PCC	3	3	0	0	3
2.	PE1102	Analysis of Electrical Machines	PCC	3	3	0	0	3
3.	PE1103	Analysis and Design of Power Converters	PCC	3	3	0	0	3
4.	PE1104	System Theory	PCC	4	3	1	0	4
5.	PE1111	Power Electronics Circuit Simulation Laboratory	PCC	4	0	0	4	2
6.	PE1112	Power Converters Laboratory	PCC	4	0	0	4	2
7.	PE1201	Analysis and Design of Inverters	PCC	3	3	0	0	3
8.	PE1202	Analysis of Electrical Drives	PCC	4	3	1	0	4
9.	PE1203	Electric Vehicle and Power Management	PCC	3	3	0	0	3
10.	PE1204	Embedded Controllers	PCC	3	3	0	0	3
11.	PE1211	Embedded Controllers Laboratory	PCC	4	0	0	4	2
12.	PE1311	Electrical Drives Laboratory	PCC	4	0	0	4	2

PROFESSIONAL ELECTIVE COURSE (PEC)

Semester II **Elective I and II**

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	PE1251	Artificial Intelligence and Machine Learning	PEC	3	3	0	0	3
2.	PE1252	Electromagnetic Field Computation and Modelling	PEC	3	3	0	0	3
3.	PE1253	Control System Design for Power Electronics	PEC	3	3	0	0	3
4.	PE1254	Analog and Digital Controllers	PEC	3	3	0	0	3
5.	PE1255	Flexible AC Transmission Systems	PEC	3	3	0	0	3

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
6.	PE1256	Modern Rectifiers and Resonant Converters	PEC	3	3	0	0	3
7.	PE1257	Electromagnetic Interference and Compatibility	PEC	3	3	0	0	3
8.	PE1258	MEMS Technology	PEC	3	3	0	0	3
9.	PE1259	Distributed Generation and Microgrid	PEC	3	3	0	0	3

Semester III **Elective III and IV**

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	PE1351	High Voltage Direct Current Transmission	PEC	3	3	0	0	3
2.	PE1352	Solar and Energy Storage Systems	PEC	3	3	0	0	3
3.	PE1353	Wind Energy Conversion Systems	PEC	3	3	0	0	3
4.	PE1354	Energy Management and Auditing	PEC	3	3	0	0	3
5.	PE1355	Non – Linear Dynamics for Power Electronics Circuit	PEC	3	3	0	0	3
6.	PE1356	Smart Grid	PEC	3	3	0	0	3
7.	PE1357	Power Electronics for Renewable Energy Systems	PEC	3	3	0	0	3
8.	PE1358	Robotics and Control	PEC	3	3	0	0	3
9.	PE1359	Non – Linear Control	PEC	3	3	0	0	3

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	PE1212	Mini Project	EEC	4	0	0	4	2
2.	PE1312	Project Work – Phase I	EEC	12	0	0	12	6
3.	PE1411	Project Work – Phase II	EEC	24	0	0	24	12

OPEN ELECTIVE COURSES [OEC]

(Out of 5 Courses one Course must be selected)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	OCP 101	Business Data Analytics	3	0	0	3	3
2.	OMF 101	Industrial Safety	3	0	0	3	
3.	OMB 103	Cost Management of Engineering Projects	3	0	0	3	
4.	OMF 102	Composite Materials	3	0	0	3	
5.	OCH 105	Waste to Energy	3	0	0	3	

AUDIT COURSES (AC)

Registration for any of these courses is optional to students

S.NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	AX1001	English for Research Paper Writing	2	0	0	0	1/2
2.	AX1002	Disaster Management	2	0	0	0	
3.	AX1003	Sanskrit for Technical Knowledge	2	0	0	0	
4.	AX1004	Value Education	2	0	0	0	
5.	AX1005	Constitution of India	2	0	0	0	
6.	AX1006	Pedagogy Studies	2	0	0	0	
7.	AX1007	Stress Management by Yoga	2	0	0	0	
8.	AX1008	Personality Development Through Life Enlightenment Skills	2	0	0	0	
Total Credits						0	

SUMMARY

M.E POWER ELECTRONICS AND DRIVES							
S. NO.	**SUBJECT AREA**	**CREDITS PER SEMESTER**				**TOTAL CREDITS**	**%**
		I	**II**	**III**	**IV**		
1.	FC	4	0	0	0	**04**	**5.33**
2.	PCC	17	15	2	0	**34**	**45.33**
3.	PEC	0	6	6	0	**12**	**16.00**
4.	RMC	2	0	0	0	**2**	**2.67**
5.	OEC	0	0	3	0	**3**	**4**
6.	EEC	0	2	6	12	**20**	**26.33**
7.	Non–Credit / Audit Course	0	0	0	0	**0**	**0.00**
	Total Credits	**23**	**23**	**17**	**12**	**75**	**100**

SEMESTER – I

MA1153	APPLIED MATHEMATICS FOR ELECTRICAL ENGINEERS	L	T	P	C
		4	0	0	4

Objectives

- The main objective of this course is to demonstrate various analytical skills in applied mathematics and extensive experience with the tactics of problem solving and logical thinking applicable for the students of electrical engineering.
- To formulate and construct a mathematical model for a linear programming problem in real life situation.
- This course also will help the students to identify, formulate, abstract, and solve problems in electrical engineering using mathematical tools from a variety of mathematical areas, including matrix theory, calculus of variations, probability, and Fourier series.

UNIT – I	MATRIX THEORY	12

Cholesky decomposition – Generalized Eigenvectors – Canonical basis – QR Factorization – Least squares method – Singular value decomposition.

UNIT – II	CALCULUS OF VARIATIONS	12

Concept of variation and its properties – Euler's equation – Functional dependant on first and higher order derivatives – Functionals dependant on functions of several independent variables – Variational problems with moving boundaries – Isoperimetric problems – Direct methods: Ritz and Kantorovich methods.

UNIT – III	PROBABILITY AND RANDOM VARIABLES	12

Probability – Axioms of probability – Conditional probability – Baye's theorem – Random variables – Probability function – Moments – Moment generating functions and their properties – Binomial, Poisson, Geometric, Uniform, Exponential, Gamma and Normal distributions – Function of a random variable.

UNIT – IV	LINEAR PROGRAMMING	12

Formulation – Graphical solution – Simplex method – Big M method – Two phase method – Transportation and Assignment models.

UNIT – V	FOURIER SERIES	12

Fourier trigonometric series: Periodic function as power signals – Convergence of series – Even and odd function: Cosine and sine series – Non periodic function: Extension to other intervals – Power signals: Exponential Fourier series – Parseval's theorem and power spectrum – Eigen value problems and orthogonal functions – Regular Sturm – Liouville systems – Generalized Fourier series.

Total Periods:	**60**

Reference Books:

1. L. C. Andrews and R. L. Phillips, 'Mathematical Techniques for Engineers and Scientists', Prentice Hall of India Pvt. Ltd., New Delhi, 2005.
2. R. Bronson, 'Matrix Operation', Schaum's outline series, 2nd Edition, McGraw Hill, 2011.
3. Isarel M. Gelfand and S.V. Fomin, 'Calculus of Variations', Dover Publication Inc,2012.
4. R. A. Johnson, I. Miller, and J. Freund, 'Miller and Freund's Probability and Statistics for Engineers', Pearson Education, Asia, 8th Edition, 2015.
5. P. V. O'Neil, 'Advanced Engineering Mathematics', Thomson Asia Pvt. Ltd., 8th Edition, Singapore, 2017.
6. Hamdy A Taha, 'Introduction to Operations Research', Prentice Hall India, Tenth Edition, Third Indian Reprint 2019.

Course Outcomes (CO)

CO1	Apply various methods in matrix theory to solve system of linear equations.
CO2	Maximizing and minimizing the functional that occurs in electrical engineering disciplines.
CO3	Computation of probability and moments, standard distributions of discrete and continuous random variables and functions of a random variable.
CO4	Could develop a fundamental understanding of linear programming models, able to develop a linear programming model from problem description, apply the simplex method for solving linear programming problems.
CO5	Fourier series analysis and its uses in representing the power signals. Able to expand the periodic and non–periodic as a power signals and Regular Sturm – Liouville systems, Generalized form of Fourier series.

Course Outcomes	**Program Outcomes**												**PSO**			
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**	**1**	**2**	**3**	**4**
CO1	3	3	3	2	2	2	1	1	1	2	2	2	3	3	3	2
CO2	3	2	2	2	1	2	1	1	1	1	1	2	3	3	3	1
CO3	2	3	2	3	2	1	1	1	1	2	1	2	3	3	3	2
CO4	3	2	2	3	3	2	2	1	1	2	2	3	3	3	3	2
C05	3	2	3	3	2	2	2	1	2	2	2	2	3	3	3	1

PE1101	POWER SEMICONDUCTOR DEVICES	L	T	P	C
		3	0	0	3

Objectives

- To improve power semiconductor device structures for adjustable speed motor control applications.
- To understand the static and dynamic characteristics of current controlled power semiconductor devices
- To understand the static and dynamic characteristics of voltage–controlled power semiconductor devices
- To enable the students for the selection of devices for different power electronics applications
- To understand the control and firing circuit for different devices.

UNIT – I	INTRODUCTION	9

Power switching devices overview - 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.

UNIT – II	CURRENT CONTROLLED DEVICES	9

BJT's - Construction, static characteristics, switching characteristics; negative temperature coefficient and second breakdown; Thyristors - Physical and electrical principle underlying operating mode, 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 & Thyristor - Basics of GTO, MCT, FCT, RCT.

UNIT – III	VOLTAGE CONTROLLED DEVICES	9

Power MOSFETs and IGBTs - Principle of voltage - Controlled devices, construction, types, static and switching characteristics, steady state and dynamic models of MOSFETs and IGBTs - and IGCT. New semiconductor materials for devices - Intelligent power modules - Integrated gate commutated thyristor (IGCT) - Comparison of all power devices.

UNIT – IV	FIRING AND PROTECTING CIRCUITS	9

Necessity of isolation, pulse transformer, optocoupler - Gate driver circuit - SCR, MOSFET, IGBTs and base driving for power BJT - Over voltage, over current and gate protections; Design of snubbers.

UNIT – V	THERMAL PROTECTION	9
Heat transfer – conduction, convection and radiation; Cooling - liquid cooling, vapour - phase cooling; Guidance for heat sink selection - Thermal resistance and impedance - Electrical analogy of thermal components, heat sink types and design - Mounting types - Switching loss calculation for power device.		
	Total Periods:	**45**

Text Books:

1. B. W. Williams, 'Power Electronics Circuit Devices and Applications'. McGraw Hill Higher Education; 2nd edition, 1992.
2. M. H. Rashid, 'Power Electronics Circuits, Devices and Applications', Prentice Hall India, Third Edition, New Delhi, 2004.

Reference Books:

1. MD Singh and K.B. Khanchandani, 'Power Electronics', Tata McGraw Hill, 2001.
2. Mohan, Undeland and Robins, 'Power Electronics – Concepts, applications and Design, John Wiley and Sons, Singapore,2000.
3. Joseph Vithayathil, Power Electronics: Principles and Applications, Delhi, Tata McGraw–Hill, 2010.

Course Outcomes (CO)

CO1	Able to understand and analyse different types of power semiconductor devices and their switching characteristics.
CO2	Able to understand and analyse different current controlled semiconductor devices and their switching characteristics.
CO3	Able to understand and analyse different voltage–controlled semiconductor devices and their switching characteristics.
CO4	Design and analyse the Firing and Protecting Circuits For various semiconductor devices
CO5	Design and analyse the cooling and thermal control of semiconductor devices

Course Outcomes	Program Outcomes												PSO			
	a	b	c	d	e	f	g	h	i	j	k	l	1	2	3	4
CO1	3	3	2	2	2	1	2	1	1	1	2	3	3	3	3	2
CO2	3	3	2	2	2	1	1	1	1	1	1	3	3	3	3	1
CO3	3	3	2	2	2	1	1	1	1	1	1	3	3	3	3	2
CO4	3	3	3	3	2	1	2	1	1	1	2	3	3	3	3	2
C05	3	3	3	3	2	1	2	1	1	1	2	3	3	3	3	1

PE1102	ANALYSIS OF ELECTRICAL MACHINES	L	T	P	C
		3	0	0	3

Objectives

- To provide knowledge about the fundamentals of magnetic circuits, energy, force and torque of multi–excited systems.
- To analyze the steady state and dynamic state operation of DC machine through mathematical modelling and simulation in digital computer.
- To provide the knowledge of theory of transformation of three phase variables to two phase variables.
- To analyze the steady state and dynamic state operation of three–phase induction machines using transformation theory based mathematical modeling and digital computer simulation.
- To analyze the steady state and dynamic state operation of three– phase synchronous machines using transformation theory based mathematical modeling and digital computer simulation.

UNIT – I	PRINCIPLES OF ELECTROMAGNETICENERGY CONVERSION	9

Magnetic circuits, Permanent magnet, Stored magnetic energy, Co–energy – Force and torque in singly and doubly excited systems – Machine windings and air gap MMF – Winding inductances and voltage equations

UNIT – II	DC MACHINES	9

Elementary DC machine and analysis of steady state operation – Voltage and torque equations dynamic characteristics of permanent magnet and shunt D.C. motors – Time domain block diagrams – Solution of dynamic characteristic by Laplace transformation – Digital computer simulation of permanent magnet and shunt D.C. Machines

UNIT – III	REFERENCE FRAME THEORY	9

Historical background – Phase transformation and Commutator transformation – Transformation of variables from stationary to arbitrary reference frame – Variables observed from several frames of reference.

UNIT – IV	INDUCTION MACHINES	9

Three phase induction machine, equivalent circuit and analysis of steady state operation – Free acceleration characteristics – Voltage and torque equations in machine variables and arbitrary reference frame variables – Analysis of dynamic performance for load torque variations – Digital computer simulation.

UNIT – V	SYNCHRONOUS MACHINES	9

Three phase synchronous machine and analysis of steady state operation – Voltage and torque equations in machine variables and rotor reference frame variables (Park's equations) – Analysis of dynamic performance for load torque variations – Generalized theory of rotating electrical machine and Kron's primitive machine.

Total Periods: 45

Text Books:

1. Paul C. Krause, Oleg Wasyzczuk, Scott S, Sudhoff, 'Analysis of Electric Machinery and Drive Systems', John Wiley, Second Edition, 2010.

Reference Books:

1. P S Bimbhra, 'Generalized Theory of Electrical Machines', Khanna Publishers, 2008.
2. A.E, Fitzgerald, Charles Kingsley, Jr, and Stephan D, Umanx, 'Electric Machinery', Tata McGraw Hill, 5th Edition, 1992.
3. R. Krishnan, 'Electric Motor & Drives: Modelling, Analysis and Control', New Delhi, Prentice Hall of India, 2001.

Course Outcomes (CO)

CO1	Ability to understand the various electrical parameters in mathematical form.
CO2	Ability to find the electrical machine equivalent circuit parameters and modelling of DC machine.
CO3	Ability to understand the different types of reference frame theories and transformation relationships.
CO4	Ability to find the electrical machine equivalent circuit parameters and modeling of Induction machine.
CO5	Ability to find the electrical machine equivalent circuit parameters and modeling of Synchronous machine.

Course Outcomes	Program Outcomes												PSO			
	a	b	c	d	e	f	g	h	i	j	k	l	1	2	3	4
CO1	3	3	3	3	1	1	1	1	1	2	1	2	3	2	3	1
CO2	3	3	2	3	3	1	1	1	1	2	1	2	3	3	3	1
CO3	3	3	3	2	3	2	1	2	2	2	1	2	3	3	3	1
CO4	3	3	3	3	2	2	1	2	2	2	2	2	3	2	3	2
C05	3	3	3	2	3	2	1	1	2	2	2	2	3	3	3	2

PE1103	ANALYSIS AND DESIGN OF POWER CONVERTERS	L	T	P	C
		3	0	0	3

OBJECTIVES

- To understand and analyse the operation, characteristics of controlled rectifiers.
- To apply switching techniques and basic topologies of DC–DC switching regulators.
- To introduce power converter components and to design the power converters.
- To provide an in–depth knowledge about resonant converters.
- To comprehend the concepts of AC–AC power converters and their applications.

UNIT – I	SINGLE PHASE & THREE PHASE CONVERTERS	9

Principle of phase–controlled converter operation – Single phase full converter and semi converter (RL, RLE load), single phase dual converter, Three phase operation full converter and semi–converter (RL, RLE load); Reactive power ; Power factor improvement techniques ; PWM rectifiers.

UNIT – II	DC–DC CONVERTERS	9

Limitations of linear power supplies; switched mode power conversion; Non–isolated DC–DC converters - operation and analysis of Buck, Boost, Buck–Boost, Cuk & SEPIC under continuous and discontinuous operation, Isolated converters- basic operation of Flyback, Forward and Push–pull topologies.

UNIT – III	DESIGN OF POWER CONVERTER COMPONENTS	9

Introduction to magnetic materials – hard and soft magnetic materials-types of cores, copper windings; Design of transformer; Inductor design equations; Inductor design for buck/ boost/ fly–back converter; Selection of output filter capacitors; Selection of ratings for devices; Input filter design.

UNIT – IV	RESONANT DC–DC CONVERTERS	9

Switching loss, hard switching, and basic principles of soft switching, Classification of resonant converters – Load resonant converters, Series and parallel; Resonant switch converters; Operation and analysis of ZVS, ZCS converters, comparison of ZCS/ZVS, ZVT/ZCT PWM converters.

UNIT – V	AC–AC CONVERTERS	9

Principle of on–off and phase angle control, Single phase ac voltage controller – Analysis with R & RL load, Three phase ac voltage controller, Principle of operation of cyclo converter – Single phase and three phase cyclo converters, Single phase matrix converters and three phase matrix converters.

Total Periods:	**45**

Text Books:

1. M. H. Rashid, 'Power Electronics Circuits, Devices and Applications', Prentice Hall India, Third Edition, New Delhi, 2017.
2. P. C. Sen, 'Modern Power Electronics', Wheeler Publishing Co, First Edition, New Delhi, 2005.
3. P. S. Bimbra, 'Power Electronics', Khanna Publishers, Eleventh Edition, 2018.

Reference Books:

1. Ned Mohan, T. M. Undeland and W.P Robbin, 'Power Electronics: converters, Application and design' John Wiley and sons. Wiley India edition, 2007.
2. P. Simon Ang, Alejandro Oliva, 'Power–Switching Converters, Second Edition, CRC Press, Taylor & Francis Group, 2010.
3. V. Ramanarayanan, 'Course material on Switched mode power conversion', 2007.
4. Alex Van den Bossche and Vencislav Cekov Valchev, 'Inductors and Transformers for Power Electronics', CRC Press, Taylor & Francis Group, 2005.
5. W. G. Hurley and W. H. Wolfle, 'Transformers and Inductors for Power Electronics Theory, Design and Applications', 2013 John Wiley & Sons Ltd.
6. Marian. K. Kazimierczuk and Dariusz Czarkowski, 'Resonant Power Converters', John Wiley & Sons limited, 2011.

Course Outcomes (CO)

CO1	Ability to understand and analyse the operation, characteristics of controlled rectifiers.
CO2	Ability to apply switching techniques and basic topologies of DC–DC switching regulators.
CO3	Ability to introduce the design of power converter components and to design the converters.
CO4	Ability to provide in–depth knowledge about resonant converters.
CO5	Ability to comprehend the concepts of AC–AC power converters and their applications

Course Outcomes	Program Outcomes												PSO			
	a	b	c	d	e	f	g	h	i	j	k	l	1	2	3	4
CO1	3	3	3	3	3	3	2	2	3	2	1	3	3	3	3	3
CO2	3	3	3	3	3	3	2	2	3	2	1	3	3	3	3	3
CO3	3	3	3	3	3	3	2	2	3	2	1	3	3	3	3	3
CO4	3	3	3	3	3	3	2	2	3	2	1	3	3	3	3	3
C05	3	3	3	3	3	3	2	2	3	2	1	3	3	3	3	3

PE1104	SYSTEM THEORY	L	T	P	C
		3	1	0	4

Objectives

- To understand the fundamentals of physical systems in terms of its linear and nonlinear models.
- To educate on representing systems in state variable form.
- To educate on solving linear and non–linear state equations.
- To exploit the properties of linear systems such as controllability and observability.
- To educate on stability analysis of systems using Lyapunov's theory.
- To educate on modal concepts and design of state and output feedback controllers and estimators.

UNIT – I	STATE VARIABLE REPRESENTATION	12

Introduction – Concept of State – State equations for Dynamic Systems – Time invariance and linearity – Non uniqueness of state model – Physical Systems and State Assignment – Free and forced responses – State Diagrams.

UNIT – II	SOLUTION OF STATE EQUATIONS	12

Existence and uniqueness of solutions to Continuous-time state equations – Solution of Nonlinear and Linear Time Varying State equations – State transition matrix and its properties – Evaluation of matrix exponential – System modes – Role of Eigen values and Eigen vectors.

UNIT – III	STABILITY ANALYSIS OF LINEAR SYSTEMS	12

Controllability and Observability – Stabilizability and Detectability – Test for Continuous-time Systems – Time varying and Time invariant case – Output Controllability – Reducibility – System Realizations.

UNIT – IV	STATE FEEDBACK CONTROL AND STATE ESTIMATOR	12

Introduction – Controllable and Observable Companion Forms – SISO and MIMO Systems – Effect of State Feedback on Controllability and Observability – Pole Placement by State Feedback for both SISO and MIMO Systems – Full Order and Reduced Order Observers.

UNIT – V	LYAPUNOV STABILTY ANALYSIS	12

Introduction – Equilibrium Points – BIBO Stability – Stability of LTI Systems – Stability in the sense of Lyapunov – Equilibrium Stability of Nonlinear Continuous-time Autonomous Systems – The Direct Method of Lyapunov and the Linear Continuous-time Autonomous Systems – Finding Lyapunov Functions for Nonlinear Continuous-time Autonomous Systems – Krasovskil's and Variable-Gradient Method.

Total Periods:	**60**

Text Books:

1. M. Gopal, 'Modern Control System Theory', New Age International, 3rd Edition 2014.
2. K. Ogatta, 'Modern Control Engineering', Pearson, 5th Edition 2012.
3. John S. Bay, 'Fundamentals of Linear State Space Systems', McGraw–Hill, 1999.

Reference Books:

1. D. Roy Choudhury, 'Modern Control Systems', New Age International, 2005.
2. John J. D'Azzo, C. H. Houpis and S. N. Sheldon, 'Linear Control System Analysis and Design with MATLAB', Taylor Francis, 2003.
3. Z. Bubnicki, 'Modern Control Theory', Springer, 2005.
4. C.T. Chen, 'Linear Systems Theory and Design', Oxford University Press, 3rd Edition, 1999.
5. M. Vidyasagar, 'Nonlinear Systems Analysis', 2nd edition, Prentice Hall, Englewood Cliffs, NewJersey.

Course Outcomes (CO)

CO1	Ability to understand the fundamentals of physical systems in terms of its linear and nonlinear models and also educate on representing systems in state variable form
CO2	Ability to understand on solving linear and non–linear state equations
CO3	Ability to represent the time–invariant systems in state space form as well as analyze, whether the system is stabilizable, controllable, observable and detectable.
CO4	Ability to design modal concepts and design of state and output feedback controllers, state observers and estimators
CO5	Ability to understand the stability analysis of systems using Lyapunov's theory.

Course Outcomes	Program Outcomes												PSO			
	a	b	c	d	e	f	g	h	i	j	k	l	1	2	3	4
CO1	3	3	3	1	2	1	1	2	1	1	3	2	1	1	3	3
CO2	3	3	3	1	2	1	1	2	1	1	3	2	1	1	3	3
CO3	3	3	3	1	2	1	1	2	1	1	3	2	1	1	3	3
CO4	3	3	3	1	2	1	1	2	1	1	3	2	1	1	3	3
C05	3	3	3	1	2	1	1	2	1	1	3	2	1	1	3	3

RM1101	RESEARCH METHODOLOGY AND IPR	L	T	P	C
	Common to CSE, AE, PED, MF, MBA, BT	2	0	0	2

Objectives

- Problem formulation, analysis and solutions.
- Technical paper writing / presentation without violating professional ethics
- Patent drafting and filing patents.

UNIT – I	RESEARCH PROBLEM FORMULATION	6

Meaning of research problem – Sources of research problem, criteria characteristics of a good research problem, errors in selecting a research problem, scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, necessary instrumentations

UNIT – II	LITERATURE REVIEW	6

Effective literature studies approaches, analysis, plagiarism, and research ethics.

UNIT – III	TECHNICALWRITING /PRESENTATION	6

Effective technical writing, how to write report, paper, developing a research proposal, format of research proposal, a presentation and assessment by a review committee.

UNIT – IV	INTRODUCTION TO INTELLECTUAL PROPERTY RIGHTS (IPR)	6

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

UNIT – V	INTELLECTUAL PROPERTY RIGHTS (IPR)	6

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System, IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

Total Periods:	30

Reference Books:

1. Asimov, 'Introduction to Design', Prentice Hall, 1962.
2. Halbert, 'Resisting Intellectual Property', Taylor & Francis Ltd, 2007.
3. Mayall, 'Industrial Design', McGraw Hill, 1992.
4. Niebel, 'Product Design', McGraw Hill, 1974.
5. Ranjit Kumar, 2nd Edition, 'Research Methodology: A Step–by–Step Guide for beginners' 2010.

Course Outcomes (CO)	
CO1	Ability to formulate research problem
CO2	Ability to carry out research analysis
CO3	Ability to follow research ethics
CO4	Ability to understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity
CO5	Ability to understand about IPR and filing patents in R & D

Course Outcomes	**Program Outcomes**												**PSO**			
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**	**1**	**2**	**3**	**4**
CO1	3	3	3	2	1	2	1	2	2	1	3	3	3	2	3	3
CO2	3	3	3	2	1	2	1	2	2	1	3	3	3	2	3	2
CO3	2	3	2	2	1	2	1	3	2	1	3	3	3	1	3	1
CO4	3	3	3	2	1	2	1	3	2	1	3	3	3	2	3	2
C05	2	3	2	2	1	2	1	3	2	1	3	3	3	1	3	2

PE1111	POWER ELECTRONICS CIRCUIT SIMULATION LABORATORY	L	T	P	C
		0	0	4	2

Objectives

- To understand the dynamics and different operating modes of power converters.
- To analyze, design and simulate different rectifier circuits for generic load.
- To simulate different DC to DC Converter topologies.
- To understand the dynamics and different operating modes of AC to AC converters.
- To simulate different inverter topologies.
- To develop skills on PCB design and fabrication among the students.

List of experiments

1. Simulation of Single - Phase Half Converter with different loads using MATLAB.
2. Simulation of Single - Phase Full Converter with different loads using MATLAB.
3. Simulation of Single - Phase Semi Converter with motor load using MATLAB.
4. Simulation of Three Phase Full Controlled Rectifier with R, RL loads using MATLAB.
5. Simulation of step - down chopper with different loads using MATLAB.
6. Simulation of Buck Converter using MATLAB.
7. Simulation of Boost Converter using MATLAB.
8. Simulation of Buck - Boost Converter using MATLAB.
9. Simulation of Single - phase half wave AC Voltage Controller with R load using MATLAB.
10. Simulation of Single - phase full wave AC Voltage Controller with R load using MATLAB.
11. Simulation of Three phase full wave AC Voltage Controller with R load using MATLAB.
12. Circuit Simulation of Voltage Source Inverter and study of spectrum analysis with and without filter using MATLAB.
13. PCB design and fabrication of DC power supply using any PCB design software (open source).

Total Periods: 60

LIST OF EQUIPMENT FOR A BATCH OF 25 STUDENTS

1. Personal Computers (Intel Core i3, 250 GB,1 GB RAM) – 10
2. Printer – 1
3. Server (Intel Core i3, 4 GB RAM) (High Speed Processor) – 1
4. Software MATLAB/SIMULINK/SCILAB/PSPICE Software – 10

Course Outcomes (CO)	
CO1	Comprehensive understanding on mathematical modeling of Rectifier and ability to implement the same using simulation tools
CO2	Ability to implement the DC to DC converter using simulation tools
CO3	Ability to implement the AC to AC converter using simulation tools
CO4	Ability to implement the DC to AC converter using simulation tools
CO5	Exposure to PCB designing and fabrication

Course Outcomes	**Program Outcomes**												**PSO**			
	a	**b**	**c**	**D**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**	**1**	**2**	**3**	**4**
CO1	3	3	3	3	3	2	1	1	1	1	1	3	3	3	2	1
CO2	3	3	3	3	3	2	1	1	1	1	1	3	3	3	2	1
CO3	3	3	3	3	3	2	1	1	1	1	1	3	3	3	2	1
CO4	3	3	3	3	3	2	1	1	1	1	1	3	3	3	2	1
C05	3	3	3	3	3	2	1	1	1	1	1	3	3	3	2	1

PE1112	POWER CONVERTERS LABORATORY	L	T	P	C
		0	0	4	2

Objectives

- To provide hands on experience with power electronic converter design and testing

List of experiments

1. Single Phase Half and Full converter with R, RL, RLE loads.
2. Voltage Commutated Chopper.
3. Current Commutated Chopper.
4. IGBT based speed control of three phase induction motor using PWM technique.
5. AC voltage regulator.
6. Series Inverter.
7. Parallel Inverter.
8. McMurray–Bedford Inverter.
9. Resonant DC to DC Converter.
10. Study of Cycloconverters.

Total Periods: 60

LIST OF EQUIPMENT FOR A BATCH OF 25 STUDENTS

1. Full converter – 2
2. IGBT/MOSFET, OPAMPS/SCR – 10
3. Single phase square wave inverter – 2
4. Regulator DC Power supplies – 5
5. CROs – 10
6. Resistive load – 5
7. Inductive load – 5
8. Capacitive load – 5
9. Breadboards – 20
10. Digital Multimeter – 10
11. Digital Storage Oscilloscope – 5
12. Single phase Isolation Transformer – 5
13. Single–phase step–down transformer – 5
14. Three phase sine PWM Inverter – 5
15. Single phase sine PWM Inverter – 5
16. Single phase auto transformer – 2
17. Three phase Auto transformer – 2

Course Outcomes (CO)	
CO1	Ability to analyze about AC to DC converter circuits.
CO2	Ability to analyze about DC to DC converter circuits.
CO3	Ability to analyze about DC to AC converters.
CO4	Ability to acquire knowledge on AC to AC converters.
CO5	Ability to understand the concepts of resonant converter and its implementation in real time applications.

Course Outcomes	**Program Outcomes**												**PSO**			
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**	**1**	**2**	**3**	**4**
CO1	3	3	3	3	3	2	1	1	1	1	1	2	3	3	2	1
CO2	3	3	3	3	3	2	1	1	1	1	1	2	3	3	2	1
CO3	3	3	3	3	3	2	1	1	1	1	1	2	3	3	2	1
CO4	3	3	3	3	3	2	1	1	1	1	1	2	3	3	2	1
C05	3	3	3	3	3	2	1	1	1	1	1	2	3	2	2	1

SEMESTER – II

PE1201	ANALYSIS AND DESIGN OF INVERTERS	L	T	P	C
		3	0	0	3

Objectives

- To Provide the electrical circuit concepts behind the different working modes of inverters so as to enable deep understanding of their operation.
- To equip with required skills to derive the criteria for the design of inverters for UPS, drives etc.,
- To analyze and comprehend the various operating modes of different configurations of inverters.
- To design different single phase and three phase inverters.
- To impart knowledge on multilevel inverters and modulation techniques

UNIT – I	SINGLE PHASE INVERTERS	9

Principle of operation of half and full bridge inverters – Performance parameters; Voltage control of single - phase inverters using various PWM techniques; Various harmonic elimination techniques; Forced commutated thyristor inverters.

UNIT – II	THREE PHASE VOLTAGESOURCE INVERTERS	9

180–degree and 120–degree conduction mode inverters with star and delta connected loads; Voltage control of three phase inverters- single, multi pulse, sinusoidal, space vector modulation techniques; Application to drive system.

UNIT – III	CURRENT SOURCE INVERTERS	9

Operation of six–step thyristor inverter – Inverter operation modes; Load commutated inverters; Auto sequential current source inverter (ASCI); Current pulsations; Comparison of current source inverter and voltage source inverters; PWM techniques for current source inverters.

UNIT – IV	MULTILEVEL & BOOST INVERTERS	9

Multilevel concept: Diode clamped, Flying capacitor, Cascade type, Comparison of multilevel inverters and its application; PWM techniques for MLI; Single phase & Three phase Impedance source inverters.

UNIT – V	RESONANT INVERTERS AND POWER CONDITIONERS	9

Series and parallel resonant inverters; Voltage control of resonant inverters – Class E resonant inverter, resonant DC–Link inverters; Power line disturbances; Power conditioners; UPS- offline UPS, online UPS.

Total Periods:	**45**

Text Books:

1. M. H. Rashid, 'Power Electronics Circuits, Devices and Applications ', Prentice Hall India, Fourth edition, New Delhi, 2017.
2. Ned Mohan, T. M. Undeland and W. P. Robbin, 'Power Electronics: converters, Application and design' John Wiley and sons. Wiley India, 3rd Edition, 2007
3. P. S. Bimbra, 'Power Electronics', Khanna Publishers, 11th Edition, 2018

Reference Books:

1. Jai P. Agrawal, 'Power Electronics Systems-Theory and design', Pearson Education, Second Edition, 2001.
2. Bimal K. Bose 'Modern Power Electronics and AC Drives', Pearson Education, Second Edition, 2015.
3. Philip T. Krein, 'Elements of Power Electronics' Oxford University Press, 2017.
4. P. C. Sen, 'Modern Power Electronics', Wheeler Publishing Co, First Edition, New Delhi, 2005.

Course Outcomes (CO)

CO1	To design and analyze working modes and operation of single phase inverters.
CO2	To design and analyze working modes and operation of three phase inverters.
CO3	To design and analyze working modes and operation of current source inverter.
CO4	To design and analyze working modes and operation of multilevel and boost inverter.
CO5	To analyze the working modes and operation of resonant inverters and power conditioners.

Course Outcomes	Program Outcomes												PSO			
	a	b	C	d	e	f	g	h	i	j	k	l	1	2	3	4
CO1	3	3	2	2	2	1	2	1	1	1	2	3	3	3	3	2
CO2	3	3	2	2	2	1	1	1	1	1	1	3	3	3	3	1
CO3	3	3	2	2	2	1	1	1	1	1	1	3	3	3	3	2
CO4	3	3	3	3	2	1	2	1	1	1	2	3	3	3	3	2
C05	3	3	3	3	2	1	2	1	1	1	2	3	3	3	3	1

PE1202	ANALYSIS OF ELECTRICAL DRIVES	L	T	P	C
		3	1	0	4

Objectives

- To study and analyze the operation of the converter fed DC drives, both qualitatively and quantitatively.
- To study and analyze the operation of the chopper fed DC drives, both qualitatively and quantitatively.
- To familiarize the students on the operation of VSI and CSI fed induction motor drives.
- To understand the field–oriented control of induction machines.
- To impart knowledge on the control of synchronous motor drives.

UNIT – I	RECTIFIER CONTROL OF DC DRIVES	9

Principle of phase control – Fundamental relations; Analysis of series and separately excited DC motor with single phase and three phase converters – Waveforms, performance parameters, performance characteristics; Continuous and discontinuous armature current operations; Current ripple and its effect on performance; Operation with freewheeling diode; Implementation of braking schemes; Drive employing dual converter.

UNIT – II	CHOPPER CONTROL OF DC DRIVES	9

Introduction to time ratio control and frequency modulation; Class A, B, C, D and E chopper – Controlled DC motor – Performance analysis, multi–quadrant control; Chopper based implementation of braking schemes; Multi–phase chopper; Related problems.

UNIT – III	CONTROL OF INDUCTION MOTOR DRIVES – STATOR SIDE AND ROTORSIDE	9

AC voltage controller circuit, six step inverter voltage control, closed loop variable frequency PWM inverter with dynamic braking, CSI fed variable frequency drives, comparison of CSI and VSI fed Drive, Static rotor resistance control, Injection of voltage in the rotor circuit, Static Scherbius drives, Power factor considerations, Modified Kramer drives.

UNIT – IV	FIELD ORIENTED CONTROL OF INDUCTION MOTOR DRIVES	9

Field oriented control of induction machines – Theory, DC drive analogy; Direct and Indirect methods; Flux vector estimation; Direct torque control of Induction Machines; Torque expression with stator and rotor fluxes; DTC control strategy.

UNIT – V	SYNCHRONOUS MOTOR DRIVES	9

Wound field cylindrical rotor motor: Equivalent circuits, Performance equations for operation from a voltage source; Starting and braking, V curves, Self–control; Margin angle control; Torque control, Power factor control, Brushless excitation systems.

Total Periods:	**45**

Text Books:

1. Gopal K. Dubey, 'Fundamentals of Electrical Drives', Narosa Publishing House, New Delhi, Second Edition, 2010.
2. R. Krishnan, 'Electric Motor Drives – Modeling, Analysis and Control', Prentice–Hall of India Pvt. Ltd., New Delhi, 2010.
3. Gopal K Dubey, 'Power Semiconductor controlled Drives', Prentice Hall Inc., New Jersy, 1989.

Reference Books:

1. N.K. De., P.K. SEN' Electric drives' PHI, 2012.
2. Bimal K Bose, 'Modern Power Electronics and AC Drives', Pearson Education Asia, 2015.
3. Vedam Subramanyam, 'Electric Drives Concepts and Applications', Second Edition, McGraw Hill, 2016.
4. W. Leonhard, 'Control of Electrical Drives', Narosa Publishing House, 1992.
5. Murphy J.M.D and Turnbull, 'Thyristor Control of AC Motors', Pergamon Press, Oxford, Delhi, 2001.

Course Outcomes (CO)

CO1	Will be able to formulate, design and analyze converter fed DC drives.
CO2	Will be able to formulate, design and analyze chopper fed DC drives.
CO3	Will acquire knowledge on the operation of VSI and CSI fed induction motor drives.
CO4	Will get expertise in the field–oriented control of Induction motor drives.
CO5	Will be able to formulate the control schemes for synchronous motor drives.

Course Outcomes	Program Outcomes												PSO			
	a	b	c	d	e	f	g	h	i	j	k	l	1	2	3	4
CO1	3	3	3	3	3	1	2	1	1	1	1	1	3	3	2	3
CO2	3	3	3	3	3	1	2	1	1	1	1	1	3	3	2	3
CO3	3	3	3	3	3	1	2	1	1	1	1	1	3	3	2	3
CO4	3	3	3	3	3	1	2	1	1	1	1	1	3	3	2	3
C05	3	3	3	3	3	1	2	1	1	1	1	1	3	3	2	3

PE1203	ELECTRIC VEHICLE AND POWER MANAGEMENT	L	T	P	C
		3	0	0	3

Objectives

- To familiarize about the significance of EV than conventional vehicles.
- To understand the concept of hybrid electric vehicles and its types with their Performance.
- To understand the EV transmission and electric propulsion using various drives.
- To understand the various converter topologies for EV vehicle.
- To understand the different strategies related to battery technology and energy storage systems.

UNIT – I	Introduction to conventional and Electric Vehicles	9

Conventional Vehicles: Internal combustion Engines – Working principle, Engine Operation Characteristics, Emission Control. EV vehicles: EV system – Configurations of EVs – Components of EV – Recent EVs and HEVs – EVs advantages – EVs market – Environmental Impact.

UNIT – II	Hybrid Electric Vehicles	9

Concept of Hybrid Electric drive, Types of Hybrids, Architectures of Hybrid Electric Drive Trains, Design of HEV, Plug–in Hybrid Electric Vehicles (PHEVs), Fuel Cell Electric Vehicles (FCEVs), Comparison of Different Vehicle Specifications

UNIT – III	Electric Trains and propulsion	9

EV Transmission configurations, Transmission components, Ideal Gearbox: Steady State Model, EV Motor Sizing. Electric Propulsion: DC motor drives, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, Configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives.

UNIT – IV	Power Converter Topologies for EV/PHEV Charging	9

Power converter topology, Grid and Photovoltaic (PV) System for EV/PHEV Charging, Design of DC/DC Converters and DC/AC Inverters for Grid/PV, Integrated converter, With and without Transformer Based Isolated Charger topology.

UNIT – V	Energy Storage and Battery management systems for EV	9

Battery Technologies – Analysis: Lead–Acid Battery, Nickel–Based Batteries, Lithium – Based Batteries – Battery parameters, Fuel cell – types and characteristics, Ultra capacitors–based energy storage and its analysis, ultra–high–speed flywheels–based energy storage and its analysis, Hybridization of energy storage devices, Battery management systems – SOC Estimation, SOH Estimation.

Total Periods:	**45**

Text Books:

1. M. Ehsani, Y. Gao, S. E. Gay and A. Emadi, 'Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design', CRC Press, 2004.
2. Iqbal Husain, 'Electric and Hybrid vehicles: Design fundamentals', CRC PRESS, Boca Raton London, New York Washington, D.C, 2005.

Reference Books:

1. C. Mi, M. A. Masrur and D. W. Gao, 'Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives', John Wiley & Sons, 2011.
2. S. Onori, L. Serrao and G. Rizzoni, 'Hybrid Electric Vehicles: Energy Management Strategies', Springer, 2015.
3. Larminie, James, and John Lowry, 'Electric Vehicle Technology Explained' John Wiley and Sons, 2012.
4. Tariq Muneer and Irene Illescas García, 'The automobile, In Electric Vehicles: Prospects and Challenges', Elsevier, 2017.
5. Sheldon S. Williamson, 'Energy Management Strategies for Electric and Plug–in Hybrid Electric Vehicles', Springer, 2013.
6. Gregory L. Plett, 'Battery Management systems', ARTECH House, London, 2016.

Course Outcomes (CO)

CO1	Learned the significance of Electric Vehicle compared to conventional vehicles.
CO2	Able to understand the concept of hybrid electric vehicles architecture with their performance.
CO3	Acquired the knowledge in EV transmission and electric propulsion using various drives train.
CO4	Ability to design the various converter topologies for EV vehicle.
CO5	Concept of different strategies related to battery technology and energy storage systems are analysed.

Course Outcomes	Program Outcomes												PSO			
	a	b	c	d	e	f	g	h	i	j	k	l	1	2	3	4
CO1	3	2	3	1	3	2	2	3	3	2	1	3	3	3	3	3
CO2	3	2	3	3	3	2	2	3	3	2	1	2	3	3	3	3
CO3	3	3	3	3	2	2	2	3	2	2	2	3	3	3	3	2
CO4	3	2	3	3	3	3	3	3	3	3	2	3	3	3	3	3
C05	3	2	2	2	3	3	3	3	3	3	2	3	3	3	3	3

PE1204	EMBEDDED CONTROLLERS	L	T	P	C
		3	0	0	3

Objectives

- To get Introduced to PIC controllers.
- To learn the concepts of ARM and DSP processors
- To learn the real–time embedded tools.
- To learn embedded –C coding of various applications
- To understand the embedded peripheral concepts with its structure and programs.

UNIT – I	Introduction to PIC Microcontroller	9

PIC 16C and PIC 16F series, PIC 18F series – Pin diagram and architecture, Pipelining, memory mapping, SFR's (Special Function Registers), Timers – Structure of timer, interrupt structure, Instruction Set – Addressing modes – Simple ASM programs.

UNIT – II	ARM PROCESSOR	9

ARM core architecture – Cortex 9, typical Pin diagram, ARM development tools, memory hierarchy, Instruction Set – Addressing modes – ASM programs for basic arithmetic operations, Co–processor.

UNIT – III	DSP PROCESSOR	9

DSP processors: TMS320C2407 – Architecture and pin diagram, General purpose Input/Output (GPIO) Functionality– Interrupts – A/D converter–Event Managers (EVA, EVB) – PWM signal generation.

UNIT – IV	Embedded tools and application programs	9

Compiler – KEIL**,** Circuit Schematic Simulation software – PROTEUS. Application Programs using C: **I**/O port handling, Keypad and multiplexed display, Timers and counters, interrupt handling, Pulse generation program, Capture and compare (CCP), A/D program.

UNIT – V	SYSTEM DESIGN – CASE STUDY	9

Voltage regulation of DC–DC converters (buck and boost converter), Stepper motor and DC motor control, Clarke's and parks transformation – Space vector PWM – Control of Induction Motors and PMSM.

Total Periods: 45

Text Books:

1. Muhammad Ali Mazidi, Rolin D. Mckinlay, Danny Causey 'PIC Microcontroller and Embedded Systems using Assembly and C for PIC18', Pearson Education, 2021.
2. S. Furber, 'ARM System on Chip Architecture' Second edition, pearson publication, 2000.
3. Hamid A. Toliyat, Steven Campbell, 'DSP based electromechanical motion control', CRC Press, 2019.

Reference Books:

1. John B. Peatman, 'Design with PIC Microcontrollers,' Pearson Education, Asia 2004.
2. John Iovine, 'PIC Microcontroller Project Book', McGraw Hill 2000.

Course Outcomes (CO)

CO1	Ability to understand the features, architectures of PIC, Ability to write the assembly language program.
CO2	Ability to understand the features, architectures of ARM Processor and ability to write the assembly language program.
CO3	Ability to understand the features, architectures of DSP Processor.
CO4	Ability to work on compiler tool and simulation software tool. Ability to develop embedded C program
CO5	Ability to grasp the embedded peripheral design concepts and its applications.

Course Outcomes	Program Outcomes												PSO			
	a	b	c	d	e	f	g	h	i	j	k	l	1	2	3	4
CO1	3	2	2	2	3	3	1	1	3	1	3	2	3	2	2	1
CO2	3	2	2	2	3	3	1	1	3	1	3	3	3	3	2	1
CO3	3	2	2	2	3	3	1	1	3	1	3	2	3	3	2	1
CO4	3	2	2	2	3	3	1	1	3	1	2	3	3	3	2	1
C05	2	3	3	3	2	2	3	3	3	1	2	3	3	2	2	1

PE1211	EMBEDDED CONTROLLERS LABOROTORY	L	T	P	C
		0	0	4	2

Objectives

- To perform simple arithmetic operations using various embedded and DSP processors.
- To perform simulation experiments of interrupts and ports interface using Keil compiler.
- To simulate circuit of power converters using Proteus along with compilation in keil compilers.

LIST OF EXPERIMENTS

1. Simple arithmetic operations using PIC, ARM.
2. Experiments using MPLAB or micro-C Compiler :
   i. I/O port handling
   ii. Timer handling using different modes
   iii. Timer as counter
   iv. External Interrupt handling program
   v. Internal interrupt handling program
3. Experiments using Proteus with keil compiler, MPLAB or micro-C Compiler :
   i) Pulse generation for DC–DC power electronic converter
   ii) Pulse generation for single phase fully controlled bridge converter
   iii) Pulse generation for H–bridge DC motor driver
   iv) Stepper motor position control.
   v) Message Display using 2–line LCD.

Total Periods: 60

LIST OF EQUIPMENT FOR A BATCH OF 25 STUDENTS

1. PIC microcontroller (3 Nos)
2. ARM Processor (3 Nos)
3. Keil Compiler (Open Source)
4. MPLAB or micro-C Compiler (Open Source)
5. Proteus (Open Source)

Course Outcomes (CO)

CO1	Acquire knowledge on interfacing peripheral devices using embedded processors
CO2	Acquire practical knowledge on embedded tools and its real–time oriented application
CO3	Ability to utilize the knowledge of embedded controllers for the application in the field of Electrical Engineering.
CO4	Acquire knowledge on advanced DSP processors and programming in embedded controllers.
CO5	Acquire practical knowledge on various embedded tools and its real–time applications.

Course Outcomes	Program Outcomes												PSO			
	a	b	c	d	e	f	g	H	i	j	k	l	1	2	3	4
CO1	3	1	1	2	3	2	2	3	1	1	1	3	1	1	3	3
CO2	3	3	2	3	3	2	2	3	2	1	1	3	1	1	3	3
CO3	3	3	3	3	3	2	2	3	2	1	1	3	1	1	3	3
CO4	3	2	3	3	3	2	2	3	2	1	1	3	1	1	3	3
CO5	3	3	3	3	3	2	2	3	2	2	2	3	1	1	3	3

PE1212	MINI PROJECT	L	T	P	C
		0	0	4	2

Objectives

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

A project to be developed based on one or more of the following concepts.
Rectifiers, DC-DC Converters, Inverters, cycloconverters, DC drives, AC drives, Special Electrical Machines, Renewable Energy Systems, Linear and non-linear control systems, Power supply design for industrial and other applications, AC-DC power factor circuits, micro grid, smart grid and robotics.

The students work on a topic approved by the head of the department and prepares a comprehensive mini project report after completing the work to the satisfaction. The progress of the project is evaluated based on a minimum of two reviews. The review committee may be constituted by the Head of the Department. A mini project report is required at the end of the semester. The mini project work is evaluated based on oral presentation and the mini project report jointly by external and internal examiners constituted by the Head of the Department.

Total Periods : 60

Course Outcomes (CO)

CO1	On Completion of the mini project work students will be in a position to take up their final year project work and find solution by formulating proper methodology.
CO2	Acquire practical knowledge within the chosen area of technology for project development.
CO3	Identify, analyze, formulate and handle programming projects with a comprehensive and systematic approach.
CO4	Contribute as an individual or in a team in development of technical projects.
CO5	Develop effective communication skills for presentation of project related activities.

Course Outcomes	Program Outcomes												PSO			
	a	b	c	d	e	f	g	H	i	j	k	l	1	2	3	4
CO1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

SEMESTER – III

PE1311	ELECTRICAL DRIVES LABORATORY	L	T	P	C
		0	0	4	2

Objectives

- To design and analyse various DC and AC drives.
- To generate the firing pulses for converters and inverters using digital processors.
- Design of controllers for linear and non-linear systems.
- Implementation of closed loop system using hardware simulation.
- To perform DSP based speed control of Switched Reluctance Motor.

LIST OF EXPERIMENTS

1. Speed control of Converter fed DC motor.
2. Speed control of Chopper fed DC motor.
3. V/f control of three–phase induction motor.
4. Micro controller–based speed control of Stepper motor.
5. Speed control of BLDC motor.
6. DSP based speed control of Switched Reluctance Motor.
7. Voltage Regulation of three–phase Synchronous Generator.
8. Cycloconverter fed Induction motor drives.
9. Single phase Multi Level Inverter based induction motor drive.
10. Study of power quality analyzer.

Total Periods: 60

LIST OF EQUIPMENTS FOR A BATCH OF 25 STUDENTS

1. Converter fed DC motor drive – 1
2. Chopper fed DC motor drive – 1
3. V/f control–based Induction motor devices – 1
4. Cyclo converter fed induction motor drive – 1
5. Three phase synchronous generator – 1
6. SRM Drive with DSP controller – 1
7. PMBLDC Drive – 1
8. Stepper motor drive with microprocessor–based control – 1
9. Single phase multilevel inverter fed with motor drive – 1
10. Power Quality Analyser – 1
11. Tachometers – 10
12. Ammeters – 10
13. Voltmeters – 10
14. Digital storage oscilloscope – 5

Course Outcomes (CO)	
CO1	Ability to simulate different types of machines, converters in a system.
CO2	Analyze the performance of various electric drive systems.
CO3	Ability to perform both hardware and software simulation.
CO4	To perform speed control of DSP based Switched Reluctance Motor.
CO5	To perform voltage regulation of three phase Synchronous Generator.

Course Outcomes	Program Outcomes												PSO			
	a	b	c	d	e	f	g	h	i	j	k	l	1	2	3	4
CO1	3	3	2	2	3	1	1	1	1	3	2	2	3	2	2	1
CO2	3	3	3	3	3	2	3	1	1	3	3	1	3	3	3	1
CO3	2	3	3	3	3	2	3	1	1	3	3	1	3	3	3	1
CO4	3	3	3	3	3	2	3	1	1	3	3	1	3	3	3	1
C05	3	3	3	3	3	2	3	1	1	3	3	1	3	3	3	1

PE1312	PROJECT WORK – PHASE I	L	T	P	C
		0	0	12	6

Objectives

To impart knowledge on

- To explore contemporary research issues.
- To perform literature survey on recent developments in a selected problem domain.
- To workout with the strategies to find a solution addressing the problem.

Course Outcomes (CO)

CO1	Demonstrate a depth of knowledge in Power Electronics and Drives
CO2	Formulate a research problem addressing contemporary technical issues.
CO3	Perform literature survey to explore various methodologies.
CO4	Undertake problem identification, formulation and solution.

Course Outcomes	Program Outcomes												PSO			
	a	b	c	d	e	f	g	H	i	j	k	l	1	2	3	4
CO1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

SEMESTER – IV

PE1411	PROJECT WORK – PHASE II	L	T	P	C
		0	0	24	12

Objectives

To impart knowledge on

- To explore contemporary research issues.
- To perform literature survey on recent developments in a selected problem domain.
- To exercise various strategies to find a solution addressing the problem.
- To compare the results with existing methodologies.
- To communicate the work done in written and oral forms.

Course Outcomes (CO)

CO1	Demonstrate a depth of knowledge in Power Electronics and Drives
CO2	Formulate a research problem addressing contemporary technical issues.
CO3	Perform literature survey to explore various methodologies.
CO4	Undertake problem identification, formulation and solution.
CO5	Assess the performance of the proposed technique with existing literature.
CO6	Communicate the research findings, in the form of publications in journals, conference proceedings etc.

Course Outcomes	Program Outcomes												PSO			
	a	b	c	d	e	f	g	H	i	j	k	l	1	2	3	4
CO1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO6	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

PROFESSIONAL ELECTIVE I & II

PE1251	ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING	L	T	P	C
		3	0	0	3

OBJECTIVES

- To impart knowledge about AI and Machine learning
- To learn and analyze the Fuzzy based expert system
- To study the basics of supervised learning and their applications.
- To understand unsupervised learning and deep learning algorithms
- To understand and apply the concept of AI / ML for real time applications.

UNIT – I	INTRODUCTION TO ARTIFICIAL INTELLIGENCE (AI)	9

History and evolution of artificial intelligence, strong AI and weak AI, definitions of Artificial Intelligence, emergence of AI – Technological advances, Machine Learning (ML) – Deep Learning, Functions of AI, Characteristics of AI, Applications of AI – Industry 4.0, education sector, Business and Finance Sector, society.

UNIT – II	AI – EXPERT SYSTEMS	9

Classical sets – Fuzzy sets – Fuzzy relations – Fuzzification – Fuzzy rules – Membership function – Knowledge base – Decision–making logic – Defuzzification – Introduction to Neuro–Fuzzy system – Adaptive Fuzzy system (Qualitative analysis).

UNIT – III	SUPERVISED LEARNING	9

Linear Models for Classification – Discriminant Functions – Probabilistic Generative Models – Probabilistic Discriminative Models – Bayesian Logistic Regression – Decision Trees – Classification Trees – Regression Trees – Pruning. Neural Networks – Feed–forward Network Functions – Error – Back propagation – Regularization – Mixture Density and Bayesian Neural Networks – Kernel Methods – Dual Representations – Radial Basis Function Networks. Ensemble methods – Bagging– Boosting (Qualitative analysis).

UNIT – IV	UNSUPERVISED LEARNING	9

Clustering – K–means – EM – Mixtures of Gaussians – The EM Algorithm in General – Model selection for latent variable models – high–dimensional spaces – The Curse of Dimensionality – Dimensionality Reduction – Factor analysis – Principal Component Analysis – Probabilistic PCA – Independent components analysis – RNN – LSTM (Qualitative analysis).

UNIT – V	REAL TIME APPLICATIONS	9

Smart cities – Vehicle Parking and Traffic Management System – smart waste and disposal management system – smart mobility – Bio–medical image processing – Inventory control – Demand Prediction for Inventory Management

Total Periods:	**45**

TEXT BOOKS:

1. S. Russell and P. Norvig, 'Artificial Intelligence: A Modern Approach', Pearson, Fourth Edition, 2020.
2. Timothy J. Ross, 'Fuzzy Logic with Engineering Applications', Tata McGraw Hill, 4th edition, 2016.
3. Ethem Alpaydin, 'Introduction to Machine Learning', PHI learning Pvt Limited, 2015

REFERENCE BOOK:

1. Dan W. Patterson 'Introduction to Artificial Intelligence and Expert Systems', Pearson Education India, 1st Edition, 2015.
2. Kevin P. Murphy, 'Machine Learning: A Probabilistic Perspective', MIT Press, 2012
3. Hastie, Tibshirani, Friedman, 'The Elements of Statistical Learning: Data Mining, Inference, and Prediction', Second Edition (Springer Series in Statistics), 2017.
4. Stephen Marsland, 'Machine Learning – An Algorithmic Perspective', Chapman and hall/CRC Press, 2nd Edition, 2014.
5. Ren, Jingzheng; Shen, Weifeng; Man, Yi; Dong, Lichun, 'Applications of Artificial Intelligence in Process Systems Engineering', Elsevier, 1st Edition, 2021.
6. Harry Collins, 'Artifictional Intelligence: Against Humanity's Surrender to Computers', Polity, 1st Edition, 2018.
7. S.N.Sivanandam and S.N.Deepa, 'Principles of Soft computing', Wiley India Edition, 3rd Edition, 2018.
8. Peter Flach, 'Machine Learning: The Art and Science of Algorithms that Make Sense of Data', Cambridge University Press, 2012

COURSE OUTCOMES (CO)

CO1	To understand the basics of AI, various subsets and applications.
CO2	To understand the concept of AI expert systems and the structure of the fuzzy Based expert system.
CO3	To understand the structure of the various supervised learning networks.
CO4	To understand the structure of the various unsupervised and deep learning networks.
CO5	To understand and implement the concept of the AI / ML algorithms for real time applications.

Course Outcomes	Program Outcomes												PSO			
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**	**1**	**2**	**3**	**4**
CO1	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1
CO2	2	2	2	3	3	1	1	2	1	2	1	2	1	1	1	1
CO3	2	2	2	3	3	1	1	2	1	2	1	2	1	1	1	1
CO4	2	2	2	3	3	1	1	2	1	2	1	2	1	1	1	1
C05	3	3	3	3	3	2	2	3	2	3	3	2	1	1	1	1

PE1252	ELECTROMAGNETIC FIELD COMPUTATION AND MODELLING	L	T	P	C
		3	0	0	3

Objectives

- To refresh the fundamentals of Electromagnetic Field Theory.
- To provide foundation in formulation and computation of Electromagnetic Fields using analytical and numerical methods.
- To impart in–depth knowledge on Finite Element Method in solving Electromagnetic field problems.
- To introduce the concept of mathematical modeling and design of electrical apparatus.

UNIT – I	INTRODUCTION	9

Review of basic field theory – Maxwell's equations – Constitutive relationships and Continuity equations – Laplace, Poisson and Helmholtz equation – principle of energy conversion – Force / torque calculation

UNIT – II	BASIC SOLUTION METHODS FOR FIELD EQUATIONS	9

Limitations of the conventional design procedure, need for the field analysis–based design, problem definition, boundary conditions, solution by analytical methods – Direct integration method – Variable separable method – Method of images, solution by numerical methods – Finite Difference Method.

UNIT – III	FORMULATION OF FINITE ELEMENT METHOD (FEM)	9

Variational Formulation – Energy minimization – Discretization – Shape functions –Stiffness matrix – 1D and 2D planar and axial symmetry problems.

UNIT – IV	COMPUTATION OF BASIC QUANTITIES USING FEM PACKAGES	9

Basic quantities – Energy stored in Electric Field – Capacitance – Magnetic Field – Linked Flux – Inductance – Force – Torque – Skin effect – Resistance.

UNIT – V	DESIGN APPLICATIONS	9

Design of Insulators – Cylindrical magnetic actuators – Transformers – Rotating machines.

Total Periods:	**45**

Reference Books:

1. Matthew. N.O. Sadiku, 'Elements of Electromagnetics', Fourth Edition, Oxford University Press, First Indian Edition2007
2. K. J. Binns, P. J. Lawrenson and C.W Trowbridge, 'The analytical and numerical solution of Electric and magnetic fields', John Wiley & Sons, 1993.
3. Nicola Biyanchi , 'Electrical Machine analysis using Finite Elements', Taylor and Francis Group, CRC Publishers, 2005.
4. Nathan Ida and Joao P. A. Bastos, 'Electromagnetics and calculation of fields', Springer Verlage, 1992.
5. S. J. Salon, 'Finite Element Analysis of Electrical Machines' Kluwer Academic Publishers, London, 1995, distributed by TBH Publishers & Distributors, Chennai, India
6. Peter P. Silvester and Ronald L. Ferrari, 'Finite Elements for Electrical Engineers' Cambridge University press, 1983.

Course Outcomes (CO)

CO1	Ability to understand the fundamental concept of electromagnetic field theory.
CO2	Ability to provide basic solution methodology for field equations.
CO3	Ability to formulate the FEM method for symmetry problems.
CO4	Ability to understand the basic quantities of field theory by using FEM package.
CO5	Apply the concepts in the design of transformer and rotating machines

Course Outcomes	Program Outcomes												PSO			
	a	b	c	d	e	f	g	h	i	j	k	l	1	2	3	4
CO1	3	3	2	1	1	1	1	1	1	1	1	3	3	1	3	1
CO2	3	3	2	2	1	1	1	1	1	1	1	3	3	1	3	1
CO3	3	3	3	2	1	1	1	1	1	1	1	3	3	1	3	1
CO4	3	3	3	2	1	1	1	1	1	1	1	3	3	1	3	2
C05	3	3	3	2	1	1	1	1	2	2	1	3	3	1	3	2

PE1253	CONTROL SYSTEM DESIGN FOR POWER ELECTRONICS	L	T	P	C
		3	0	0	3

Objectives

- To explore conceptual bridges between the fields of Control Systems and Power Electronics
- To Study Control theories and techniques relevant to the design of feedback controllers in Power Electronics.

UNIT – I	MODELLING OF DC–TO–DC POWER CONVERTERS	9

Modelling of Buck Converter, Boost Converter, Buck–Boost Converter, Cuk Converter, SEPIC Converter, Zeta Converter, Quadratic Buck Converter, Double Buck–Boost Converter, Boost–Boost Converter General Mathematical Model for Power Electronics Devices.

UNIT – II	SLIDING MODE CONTROLLER DESIGN	9

Variable Structure Systems. Single Switch Regulated Systems Sliding Surfaces, Accessibility of the Sliding Surface Sliding Mode Control Implementation of Boost Converter, Buck–Boost Converter, Cuk Converter, SEPIC Converter, Zeta Converter, Quadratic Buck Converter, Double Buck–Boost Converter, Boost–Boost Converter.

UNIT – III	APPROXIMATE LINEARIZATION CONTROLLER DESIGN	9

Linear Feedback Control, Pole Placement by Full State Feedback, Pole Placement Based on Observer Design, Reduced Order Observers, Generalized Proportional Integral Controllers, Passivity Based Control, Sliding Mode Control Implementation of Buck Converter, Boost Converter, Buck–Boost Converter

UNIT – IV	NONLINEAR CONTROLLER DESIGN	9

Feedback Linearization Isidori's Canonical Form, Input–Output Feedback Linearization, State Feedback Linearization, Passivity Based Control, Full Order Observers, Reduced Order Observers

UNIT – V	PREDICTIVE CONTROL OF POWER CONVERTERS	9

Basic Concepts, Theory, and Methods, Application of Predictive Control in Power Electronics, AC–DC–AC Converter System, Faults and Diagnosis Systems in Power Converters.

Total Periods:	**45**

Reference Books:

1. Hebertt Sira–Ramírez, Ramón Silva–Ortigoza, 'Control Design Techniques in Power Electronics Devices', Springer, 2012.
2. Mahesh Patil, Pankaj Rodey, 'Control Systems for Power Electronics: A Practical Guide', Springer India, 2015.
3. Blaabjerg José Rodríguez, 'Advanced and Intelligent Control in Power Electronics and Drives', Springer,2014
4. Enrique Acha, Vassilios Agelidis, Olimpo Anaya, TJE Miller, 'Power Electronic Control in Electrical Systems', Newnes, 2002
5. Marija D. Aranya Chakrabortty, Marija, 'Control and Optimization Methods for Electric Smart Grids', Springer, 2012.

Course Outcomes (CO)

CO1	Ability to understand and model the different types of DC–DC power converters.
CO2	Ability to gain knowledge on sliding mode controller design.
CO3	Ability to understand an overview on modern linear control strategies for power electronics devices
CO4	Ability to understand an overview on modern nonlinear control strategies for power electronics devices
CO5	Ability to model modern power electronic converters for industrial applications and to design appropriate controllers for modern power electronics devices.

Course Outcomes	Program Outcomes												PSO			
	a	b	C	d	e	f	g	h	i	j	k	l	1	2	3	4
CO1	3	3	3	2	1	1	1	1	1	1	3	3	3	2	3	1
CO2	3	3	3	2	1	1	1	1	1	1	3	3	3	2	3	2
CO3	3	3	3	2	2	1	1	1	1	1	2	3	3	2	3	1
CO4	3	3	3	2	2	1	1	1	1	1	2	3	3	2	3	2
C05	3	3	3	2	2	1	1	1	1	1	2	3	3	2	3	2

PE1254	ANALOG AND DIGITAL CONTROLLERS	L	T	P	C
		3	0	0	3

Objectives

- To provide an overview of the control system and converter control methodologies
- To provide an insight to the analog controllers generally used in practice
- To impart basic knowledge about digital controllers.
- To study on the driving techniques, isolation requirements, signal conditioning and protection methods
- To implement an analog and a digital controller on a converter

UNIT – I	CONTROL SYSTEM–OVERVIEW	9

Feedback and Feed–forward control, Right Half Plane Zero, Gain margin and Phase Margin, Stability, Analysis and Transfer function of P, PI, PD and PID controllers and its effects. Voltage mode control, Peak Current mode Control, Average Current mode Control for Converters – Need, advantages and disadvantages.

UNIT – II	ANALOG CONTROLLERS	9

Major components of a controller – Op–Amp based PI and PID controller – Proportional, Integral and Differential gains in terms of Resistance and Capacitance, Error Amplifiers, PWM generator using Ramp or Triangular generator and comparator, and Driver, Voltage mode controller design using UC3524, Peak Current mode controller design using UC3842, Average Current mode controller design using UC3854.

UNIT – III	DIGITAL CONTROLLERS	9

Micro Controllers and Digital Signal Controllers for Converter Control Application, Interface Modules for Converter Control – A/D, Capture, Compare and PWM, Analog Comparators for instantaneous over current detection, Interrupts, Discrete PI and PID equations, Algorithm for PI and PID implementation, Example Code for PWM generation.

UNIT – IV	SIGNAL CONDITIONING, DRIVER, ISOLATION AND PROTECTION	9

Voltage feedback sensing circuits, Hall effect sensors and Shunts for current feedback sensing, Low offset Op–Amps for signal conditioning, Single and dual supply op–amps, Totem pole drivers, need for isolated drivers, optically isolated drivers, Low side drivers, High side drivers with bootstrap power supply, Vce sat sensing, CT based Device current sensing and pulse blocking.

UNIT – V	CONTROLLER IMPLEMENTATION	9

Analog and Digital Controller Design for Buck Converter – Power circuit transfer function and bode plot, PI controller bode plot, combined bode plot with required Gain and Phase margins, Implementation of Analog controller and Digital controller.

Total Periods: 45

Text Books:

1. I.J. Nagrath and M. Gopal, 'Control Systems Engineering', New Age International Publishers, 6th edition, 2018.
2. George Ellis, 'Control System Design Guide', Elsevier, (Fourth Edition), 2012.
3. Ioan Doré Landau, Gianluca Zito, 'Digital Control Systems: Design, Identification and Implementation', Springer, 2010.

Reference Books:

1. TI Application notes, Reference Manuals and Data sheets.
2. Agilent Data Sheets.
3. Microchip application notes, Reference Manuals and Data sheets.

Course Outcomes (CO)

CO1	Acquire knowledge on control system and converter control methodologies
CO2	Understand the analog controllers generally used in practice
CO3	Study the embedded Processers for Digital Control
CO4	Understand the driving techniques, isolation requirements, signal and conditioning protection methods
CO5	Implementing an analog and a digital controller on a converter

Course Outcomes	Program Outcomes												PSO			
	a	b	c	d	e	f	g	h	i	j	k	l	1	2	3	4
CO1	3	2	3	2	1	3	2	1	2	1	1	3	3	2	3	2
CO2	3	3	3	2	1	3	2	1	2	1	2	3	3	2	3	2
CO3	3	3	3	2	1	3	2	1	2	1	2	3	3	2	3	3
CO4	3	3	2	1	1	3	2	1	2	1	2	3	3	2	3	1
CO5	3	2	3	1	1	3	2	1	2	1	3	3	3	2	3	1

PE1255	FLEXIBLE AC TRANSMISSION SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES

- The problems in AC transmission systems and establish the Flexible AC transmission systems.
- The operation and control of SVC and its applications to enhance the stability and damping.
- The different modes of operation TCSC and to model it for power flow and stability studies.
- The basic operation and control of voltage source converter–based FACTS controllers.
- The advanced FACTS controllers

UNIT – I	INTRODUCTION	9

Reactive power control in electrical power transmission lines – loads & system compensation, Uncompensated transmission line – shunt and series compensation. Basic concepts of Static Var Compensator (SVC) – Thyristor Controlled Series Capacitor (TCSC)

UNIT – II	SHUNT COMPENSATION USING STATIC VAR COMPENSATOR	9

Voltage control by SVC – Advantages of slope in dynamic characteristics – Influence of SVC on system voltage – Design of SVC voltage regulator – Modelling of SVC for power flow and fast transient stability – Applications: Enhancement of transient stability – Steady state power transfer – Enhancement of power system damping.

UNIT – III	THYRISTOR CONTROLLER BASED SERIES CAPACITOR, GTO AND APPLICATIONS	9

Operation of the TCSC – Different modes of operation – Modelling of TCSC, Variable reactance model– Modelling for Power Flow and stability studies. Applications: Improvement of the system stability limit – Enhancement of system damping, GTO Characteristics and applications.

UNIT – IV	VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS	9

Static Synchronous Compensator (STATCOM) – Principle of operation – V–I Characteristics. Applications: Steady state power transfer – Enhancement of transient stability – Prevention of voltage instability. SSSC – Operation of SSSC and the control of power flow – Modelling of SSSC in load flow and transient stability studies.

UNIT – V	ADVANCED CONTROLLERS AND COORDINATION BETWEEN FACTS CONTROLLERS	9

Interline DVR (IDVR) – Unified Power flow controller (UPFC) – Interline power flow controller (IPFC) – Unified Power quality conditioner (UPQC). FACTS Controller interactions – SVC–SVC interaction – Co–ordination of multiple controllers using linear control techniques – Quantitative treatment of control coordination.

Total Periods:	**45**

TEXT BOOKS:

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

Reference Books:

1. K.R. Padiyar, 'FACTS Controllers in Power Transmission and Distribution', New Age International (P) Limited, Publishers, New Delhi, 2008.
2. V. K. Sood, 'HVDC and FACTS controllers – Applications of Static Converters in Power System', April 2004, Kluwer Academic Publishers, 2004.

COURSE OUTCOMES (CO)

CO1	Analyse the reactive power flow in transmission networks and understand the importance of voltage stability
CO2	Analyse and understand the operation of shunt compensated devices namely SVC
CO3	Analyse and understand the operation of series compensated devices namely TCSC and GTO
CO4	Acquire knowledge about the effectiveness of active compensation and usage of SSSC
CO5	Acquire knowledge about new age compensators and their interaction with the system.

Course Outcomes	**Program Outcomes**												**PSO**			
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**	**1**	**2**	**3**	**4**
CO1	3	3	2	2	1	1	1	1	1	1	1	1	3	1	2	1
CO2	3	3	3	1	1	1	1	1	1	1	1	1	3	2	1	1
CO3	3	2	2	3	1	1	1	1	1	1	1	1	3	3	1	1
CO4	2	3	2	1	2	1	3	1	1	1	1	1	2	2	1	1
C05	3	1	3	1	3	1	1	1	1	1	1	3	1	3	1	1

PE1256	MODERN RECTIFIERS AND RESONANT CONVERTERS	L	T	P	C
		3	0	0	3

Objectives

- To gain knowledge about the harmonic's standards and operation of rectifiers in CCM & DCM.
- To analyze and design power factor correction rectifiers for UPS applications.
- To know the operation of resonant converters for SMPS applications.
- To carry out dynamic analysis of DC– DC Converters.
- To introduce the source current shaping methods for rectifiers

UNIT – I	POWER SYSTEM HARMONICS & LINECOMMUTATEDRECTIFIERS	9

Average power – RMS value of waveform – Effect of Power factor – Current and voltage harmonics – Effect of source and load impedance – AC line current harmonic standards IEC1000 – IEEE 519 – CCM and DCM operation of single–phase full wave rectifier – Behavior of full wave rectifier for large and small values of capacitance – CCM and DCM operation of three phase full wave rectifier – 12 pulse converters – Harmonic trap filters

UNIT – II	PULSE WIDTH MODULATED RECTIFIERS	9

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 – PWM concepts – Device selection for rectifiers – IGBT based PWM rectifier, comparison with SCR based converters with respect to harmonic content – Applications of rectifiers.

UNIT – III	RESONANTCONVERTERS	9

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 – IV	DYNAMIC ANALYSIS OFSWITCHINGCONVERTERS	9

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 – V	SOURCE CURRENT SHAPINGOF RECTIFIERS	9

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.

Total Periods:	**45**

Reference Books:

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', CRC Press, Taylor & Francis Group, 2019.
3 Simon Ang and Alejandro Oliva, 'Power Switching Converters', Taylor & Francis Group, 2010.
4 Andrzej M. Trzynadlowski, 'Introduction to Modern Power Electronics', John Wiley & Sons, 2016.
5 Marian. K. Kazimierczuk and Dariusz Czarkowski, 'Resonant Power Converters', John Wiley & Sons limited, 2011.
6 Keng C. Wu, 'Switch Mode Power Converters – Design and Analysis', Elseveir academic press, 2006.
7 Abraham I. Pressman, Keith Billings and Taylor Morey, 'Switching Power Supply Design' McGraw–Hill, 2009
8 V. Ramanarayanan, 'Course Material on Switched Mode Power Conversion', IISC, Banglore, 2007.
9 Christophe P. Basso, Switch–Mode Power Supplies, McGraw–Hill, 2014.

Course Outcomes (CO)

CO1	Apply the concept of various types of rectifiers.
CO2	Simulate and design the operation of resonant converter and its importance.
CO3	Identify the importance of linear system, state space model, PI controller.
CO4	Design the DC power supplies using advanced techniques.
CO5	Understand the standards for supply current harmonics and its significance.

Course Outcomes	Program Outcomes												PSO			
	a	b	c	d	e	f	g	h	i	j	k	l	1	2	3	4
CO1	3	3	3	3	3	1	3	1	1	1	1	1	3	3	3	1
CO2	3	3	3	3	3	1	3	1	1	1	1	1	3	3	3	1
CO3	3	3	3	3	3	1	3	1	1	1	1	1	3	3	3	1
CO4	3	3	4	3	3	1	3	1	1	1	1	1	3	3	3	1
C05	3	3	4	3	3	1	3	1	1	1	1	1	3	3	3	1

PE1257	ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY	L	T	P	C
		3	0	0	3

Objectives

- To provide fundamental knowledge on electromagnetic interference and electromagnetic compatibility.
- To study the important techniques to control EMI and EMC. To expose the knowledge on testing techniques as per Indian and international standards in EMI measurement.

UNIT – I	INTRODUCTION	9

Definitions of EMI/EMC - sources of EMI - Inter systems and Intra system - Conducted and radiated interference - Characteristics - Design for electromagnetic compatibility (EMC) - EMC regulation typical noise path - EMI predictions and modelling, Cross talk - Methods of eliminating interferences.

UNIT – II	GROUNDING AND CABLING	9

Cabling - types of cables, mechanism of EMI emission / coupling in cables - Capacitive coupling inductive coupling - Shielding to prevent magnetic radiation - Shield transfer impedance, Grounding - Safety grounds - Signal grounds - Single point and multipoint ground systems hybrid grounds - Functional ground layout - Grounding of cable shields - Guard shields - isolation, neutralizing transformers, shield grounding at high frequencies, digital grounding - Earth measurement Methods.

UNIT – III	BALANCING, FILTERING AND SHIELDING	9

Power supply decoupling - Decoupling filters - Amplifier filtering - High frequency filtering - EMI filters characteristics of LPF, HPF, BPF, BEF and power line filter design - Choice of capacitors, inductors, transformers and resistors, EMC design components - Shielding - Near and far fields shielding effectiveness - Absorption and reflection loss - Magnetic materials as a shield, shield discontinuities, slots and holes, seams and joints, conductive gaskets - Windows and coatings - Grounding of shields

UNIT – IV	EMI IN ELEMENTS AND CIRCUITS	9

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

UNIT – V	ELECTROSTATIC DISCHARGE, STANDARDS AND TESTING	9

Static Generation - Human body model - Static discharges - ESD versus EMC, ESD protection in equipment's - Standards - FCC requirements - EMI measurements - Open area test site measurements and precautions - Radiated and conducted interference measurements, Control requirements and testing methods.

Total Periods:	**45**

Reference Books:

1. V.P. Kodali, 'Engineering Electromagnetic Compatibility', S. Chand, 1996.
2. Henry W. Ott, 'Noise reduction techniques in electronic systems', John Wiley & Sons, 1989.
3. Bernhard Keiser, 'Principles of Electro–magnetic Compatibility', Artech House, Inc. 1987.
4. J. E. Bridges, J. Milleta and L. W. Ricketts., 'EMP Radiation and Protective techniques', John Wiley and sons, USA, 1976.
5. G. William Duff, & R. J. Donald White, 'A handbook Series on Electromagnetic Interference and Compatibility', Interference Control Technologies, Inc. 1988.
6. A. Weston David, 'Electromagnetic Compatibility, Principles and Applications', CRC Press, 2006.

Course Outcomes (CO)

CO1	To understand the basic definition, sources of EMI and the design of EMC.
CO2	To understand the design of cabling and grounding for EMC.
CO3	To understand the various EMI filters and the shielding design for EMC.
CO4	To understand the various sources of EMI in power systems and its effect.
CO5	To understand the electrostatic discharge, standards and various measurement techniques of EMI.

Course Outcomes	**Program Outcomes**												**PSO**			
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**I**	**j**	**k**	**L**	**1**	**2**	**3**	**4**
CO1	3	3	2	2	1	1	1	1	1	1	3	3	1	1	3	3
CO2	3	3	2	2	2	1	1	1	1	1	3	3	1	1	3	3
CO3	3	3	3	3	2	1	2	1	1	1	3	3	1	1	3	3
CO4	3	2	3	3	3	1	2	1	1	1	3	3	1	1	3	2
C05	3	2	3	3	3	1	3	1	1	1	3	3	1	1	3	2

PE1258	MEMS TECHNOLOGY	L	T	P	C
		3	0	0	3

Objectives

- To teach the students properties of materials, micro structure and fabrication methods.
- To teach the design and modeling of Electrostatic sensors and actuators.
- To teach the characterizing thermal sensors and actuators through design and modeling.
- To teach the fundamentals of piezoelectric sensors and actuators through exposure to different MEMS and NEMS devices.
- To involve Discussions / Practice / Exercise onto revising & familiarizing the concepts acquired over the 5 units of the subject for improved employability skills.

UNIT – I	MICRO–FABRICATION, MATERIALS AND ELECTRO–MECHANICAL CONCEPTS	9

Overview of micro fabrication - Silicon and other material based fabrication processes - Concepts: Conductivity of semiconductors - Crystal planes and orientation - stress and strain - flexural beam bending analysis - Torsional deflections - Intrinsic stress - Resonant frequency and quality factor.

UNIT – II	ELECTROSTATIC SENSORS AND ACTUATION	9

Principle, material, design and fabrication of parallel plate capacitors as electrostatic sensors and actuators - Applications.

UNIT – III	THERMAL SENSING AND ACTUATION	9

Principle, material, design and fabrication of thermal couples, thermal bimorph sensors, thermal resistor sensors - Applications.

UNIT – IV	PIEZOELECTRIC SENSING AND ACTUATION	9

Piezoelectric effect - Cantilever piezoelectric actuator model - Properties of piezoelectric materials - Applications.

UNIT – V	CASE STUDIES	9

Piezo resistive sensors, Magnetic actuation, Micro fluidics applications, medical applications, Optical MEMS – NEMS Devices

Note: Class room discussions and tutorials can include the following guidelines for improved teaching /learning process: Discussions/Exercise/Practice on Workbench: on the basics /device model design aspects of thermal/peizo/resistive sensors etc.

Total Periods: 45

Text Books:

1.Vikas Choudhary ,Krzysztof Iniewski, "MEMS fundamental Technology and Applications"1st Edition 2017.

Reference Books:

1. Chang Liu, 'Foundations of MEMS', Pearson publications, 2nd Edition, 2011.
2. Marc Madou, 'Fundamentals of micro fabrication', CRC Press, 2nd Edition, 2002.
3. Boston, 'Micro machined Transducers Sourcebook', WCB McGraw Hill, 1998.
4. M. H. Bao 'Micromechanical transducers: Pressure sensors, accelerometers and gyroscopes', Elsevier, New york, 2000.

Course Outcomes (CO)

CO1	Understand basics of micro fabrication, develop models and simulate electrostatic and electromagnetic sensors and actuators.
CO2	Understand material properties, important for MEMS system performance, analyze dynamics of resonant micro mechanical structures.
CO3	The learning process delivers insight onto design of micro sensors, embedded sensors & actuators in power aware systems like grid.
CO4	Understand the design process and validation for MEMS devices and systems, and learn the state of the art in optical micro systems.
CO5	Improved Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in embedded systems design.

Course Outcomes	Program Outcomes												PSO			
	a	**b**	**c**	**d**	**e**	**F**	**g**	**h**	**i**	**j**	**k**	**l**	**1**	**2**	**3**	**4**
CO1	3	3	3	3	2	1	1	1	1	1	2	3	3	2	3	2
CO2	3	3	3	3	2	1	1	1	1	1	2	3	3	2	3	2
CO3	3	3	3	3	2	1	1	1	1	1	2	3	3	2	3	2
CO4	3	3	3	3	2	1	1	1	1	1	2	3	3	2	3	2
C05	3	3	3	3	2	1	1	1	1	1	2	3	3	2	3	2

PE1259	DISTRIBUTED GENERATION AND MICROGRID	L	T	P	C
		3	0	0	3

Objectives

- To illustrate the concept of distributed generation and its topologies.
- To analyze the impact of grid integration.
- To study concept of Microgrid and its configuration.
- To understand various modes of operation and control of micro grid.

UNIT – I	INTRODUCTION	9

Conventional power generation: advantages and disadvantages, Energy crises, Non–conventional energy (NCE) resources: review of Solar PV, Wind Energy systems, Fuel Cells, micro–turbines, biomass, and tidal sources.

UNIT – II	DISTRIBUTED GENERATIONS (DG)	9

Concept of distributed generations, topologies, selection of sources, regulatory standards/ framework, Standards for interconnecting Distributed resources to electric power systems: IEEE 1547. DG installation classes, security issues in DG implementations. Energy storage elements: Batteries, ultra–capacitors, flywheels. Captive power plants.

UNIT – III	IMPACT OF GRID INTEGRATION	9

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 – IV	BASICS OF A MICROGRID	9

Concept and definition of Microgrid, Microgrid drivers and benefits, review of sources of Microgrids, typical structure and configuration of a Microgrid, AC and DC microgrids, Power Electronics interfaces in DC and AC Microgrids.

UNIT – V	CONTROL AND OPERATION OF MICROGRID	9

Modes of operation and control of Microgrid: grid connected and islanded mode, Active and reactive power control, protection issues, anti–islanding schemes: passive, active and communication–based techniques, Microgrid communication infrastructure, Power quality issues in Microgrids, regulatory standards, Microgrid economics, Introduction to smart Microgrids.

Total Periods:	**45**

Reference Books:

1. Amirnaser Yezdani, and Reza Iravani, 'Voltage Source Converters in Power Systems: Modeling, Control and Applications', IEEE John Wiley Publications, 2010.
2. Dorin Neacsu, 'Power Switching Converters: Medium and High Power', CRC Press, Taylor & Francis, 2006.
3. Chetan Singh Solanki, 'Solar Photo Voltaics', PHI learning Pvt. Ltd., NewDelhi,2009
4. J.F. Manwell, J.G. McGowan 'Wind Energy Explained, theory design and applications', Wiley publication2010.
5. D. D. Hall and R. P. Grover, 'Biomass Regenerable Energy', John Wiley, New York, 1987.
6. John Twidell and Tony Weir, 'Renewable Energy Resources' Taylor and Francis Publications, Second edition 2006.

Course Outcomes (CO)

CO1	Understand the various conventional and non-conventional sources of electrical energy.
CO2	Understand the various topologies, standards and energy storage elements of the distributed generations.
CO3	Understand the grid integration, stability and power quality issues of distributed generations.
CO4	Understand the different configurations and interfaces of the Microgrid.
CO5	Understand the control of Microgrids and the concept of smart Microgrids.

Course Outcomes	Program Outcomes												PSO			
	a	b	c	d	e	f	g	h	i	j	k	l	1	2	3	4
CO1	3	3	3	1	2	1	1	2	1	1	3	2	1	1	3	3
CO2	3	3	3	1	2	1	1	2	1	1	3	2	1	1	3	3
CO3	3	3	3	1	2	1	1	2	1	1	3	2	1	1	3	3
CO4	3	3	3	1	2	1	1	2	1	1	3	2	1	1	3	3
C05	3	3	3	1	2	1	1	2	1	1	3	2	1	1	3	3

PROFESSIONAL ELECTIVE – III & IV

PE1351	HIGH VOLTAGE DIRECT CURRENT TRANSMISSION	L	T	P	C
		3	0	0	3

Objectives

- To impart knowledge on operation, modelling and control of HVDC link.
- To perform steady state analysis of AC/DC system.
- To expose various HVDC simulators.

UNIT – I	DC POWER TRANSMISSION TECHNOLOGY	9

Introduction – Comparison of AC and DC transmission – Application of DC transmission – Description of DC transmission system – Planning for HVDC transmission – Modern trends in DC transmission – DC breakers – Cables, VSC based HVDC.

UNIT – II	THYRISTOR BASED HVDC CONVERTERS AND HVDC SYSTEM CONTROL	9

Pulse number, choice of converter configuration – Simplified analysis of Graetz circuit – Converter bridge characteristics – Characteristics of a twelve–pulse converter – Detailed analysis of converters. General principles of DC link control – Converter control characteristics – System control hierarchy – Firing angle control – Current and extinction angle control – Generation of harmonics and filtering – Power control – Higher level controllers – Valve tests

UNIT – III	MULTI TERMINAL DC SYSTEMS	9

Introduction – Potential applications of MTDC systems – Types of MTDC systems – Control and protection of MTDC systems – Study of MTDC systems

UNIT – IV	POWER FLOW ANALYSIS IN AC/DC SYSTEMS	9

Per unit system for DC Quantities – Modelling of DC links – Solution of DC load flow – Solution of AC–DC power flow – Unified, Sequential and Substitution of power injection method

UNIT – V	SIMULATION OF HVDC SYSTEMS	9

Introduction – DC LINK Modelling, Converter Modeling and State Space Analysis, Philosophy and tools – HVDC system simulation, online and off–line simulators – Dynamic interactions between DC and AC systems

Total Periods:	**45**

Text Books:

1 P. Kundur, 'Power System Stability and Control', McGraw–Hill,1993
2 K. R. Padiyar, 'HVDC Power Transmission Systems', New Age International (P) Ltd., New Delhi, 2002.
3 S. Rao, 'EHV–AC, HVDC Transmission and Distribution Engineering', Third Edition. 2013.

Reference Books:

1 J. Arrillaga, 'High Voltage Direct Current Transmission', Peter Pregrinus, London, 1983.
2 Erich Uhlmann, 'Power Transmission by Direct Current', BS Publications, 2004.
3 V. K. Sood, HVDC and FACTS controllers – Applications of Static Converters in Power System, April 2004, Kluwer Academic Publishers

Course Outcomes (CO)

CO1	Ability to understand the DC power Transmission technology and their related components.
CO2	Ability to understand the analysis of HVDC converters principles and control
CO3	Ability to understand about the Multi Terminal HVDC Systems
CO4	Ability to understand the power flow analysis in DC system
CO5	Ability to model and simulate the HVDC systems

Course Outcomes	**Program Outcomes**												**PSO**			
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**	**1**	**2**	**3**	**4**
CO1	3	2	2	1	1	2	1	2	1	1	1	2	3	2	1	2
CO2	3	2	2	1	1	2	1	2	1	1	1	2	3	2	1	2
CO3	3	2	2	1	1	2	1	2	1	1	1	2	3	2	1	2
CO4	3	2	2	1	1	2	1	2	1	1	1	2	3	2	1	2
CO5	3	3	3	3	3	2	1	2	1	1	1	2	3	2	1	2

PE1352	SOLAR AND ENERGY STORAGE SYSTEMS	L	T	P	C
		3	0	0	3

Objectives

- To Study about solar modules and PV system design and their applications.
- To Deal with grid connected PV systems.
- To Discuss about different energy storage systems.

UNIT – I	INTRODUCTION	9

Characteristics of sunlight – Semiconductors and P–N junctions – Behaviour of solar cells – Cell properties – PV cell interconnection.

UNIT – II	STAND ALONE PV SYSTEM	9

Solar modules – Storage systems – Power conditioning and regulation – MPPT– Protection – Stand–alone PV systems design – Sizing.

UNIT – III	GRID CONNECTED PV SYSTEMS	9

PV systems in buildings – Design issues for central power stations – Safety – Economic aspect – Efficiency and performance – International PV programs.

UNIT – IV	ENERGY STORAGE SYSTEMS	9

Impact of intermittent generation – Battery energy storage – Solar thermal energy storage – Pumped hydroelectric energy storage.

UNIT – V	APPLICATIONS	9

Water pumping – Battery chargers – Solar car – Direct–drive applications – Space – Telecommunications.

Total Periods: 45

Text Books:

1. Solanki C.S., 'Solar Photovoltaics: Fundamentals, Technologies and Applications', PHI Learning Pvt. Ltd., 2015.
2. Stuart R. Wenham, Martin A. Green, Muriel E. Watt and Richard Corkish, 'Applied Photovoltaics', Third edition, 2012, Earthscan, UK.

Reference Books:

1. Eduardo Lorenzo G. Araujo, 'Solar electricity engineering of photovoltaic systems', Progensa, 1994.
2. Frank S. Barnes & Jonah G. Levine, 'Large Energy storage Systems Handbook', CRC Press, 2011.
3. McNeils, Frenkel, Desai, 'Solar & Wind Energy Technologies', Wiley Eastern, 1990.
4. S. P. Sukhatme, 'Solar Energy', Fourth edition, Tata McGraw Hill Education, 2017.

Course Outcomes (CO)	
CO1	Students will develop more understanding on solar radiation and solar cell interconnections.
CO2	Students will develop basic knowledge on standalone PV system.
CO3	Students will understand the issues in grid connected PV systems.
CO4	Students will study about the modelling of different energy storage systems and their performances.
CO5	Students will attain more on different applications of solar energy.

Course Outcomes	**Program Outcomes**												**PSO**			
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**	**1**	**2**	**3**	**4**
CO1	3	3	3	3	2	3	3	3	2	2	1	2	3	2	2	2
CO2	2	3	3	3	3	3	3	3	3	3	1	2	2	3	3	3
CO3	2	2	3	3	3	2	2	3	3	3	1	2	1	2	3	3
CO4	3	3	2	3	3	3	3	3	2	2	1	2	3	3	3	2
CO5	3	3	3	3	2	2	3	3	2	2	1	2	3	2	2	2

PE1353	WIND ENERGY CONVERSION SYSTEMS	L	T	P	C
		3	0	0	3

Objectives

- To learn basic scientific working principles, various parts design and efficiency computation theories of wind turbine.
- To learn the design and control principles of Wind turbine.
- To understand the concepts of fixed speed wind energy conversion systems.
- To understand the concepts of variable speed wind energy conversion systems.
- To analyze the grid integration and its issues.

UNIT – I	INTRODUCTION	9

Components of WECS – WECS schemes – Power obtained from wind – Simple momentum theory – Power coefficient – Sabinin's theory – Aerodynamics of Wind turbine.

UNIT – II	WIND TURBINES	9

HAWT – VAWT – Power developed – Thrust–Efficiency – Rotor selection – Rotor design considerations – Tip speed ratio – No. of Blades – Blade profile – Power Regulation – Yaw control – Pitch angle control – Stall control – Schemes for maximum power extraction.

UNIT – III	FIXED SPEED SYSTEMS	9

Generating Systems – Constant speed constant frequency systems – Choice of Generators– Deciding factors – Synchronous Generator – Squirrel Cage Induction Generator – Model of Wind Speed – Model wind turbine rotor – Drive Train model – Generator model for Steady state and Transient stability analysis.

UNIT – IV	VARIABLESPEED SYSTEMS	9

Need of variable speed systems – Power–wind speed characteristics – Variable speed constant frequency systems synchronous generator – DFIG – PMSG – Variable speed generators modeling Variable speed variable frequency schemes.

UNIT – V	GRID CONNECTED SYSTEMS	9

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.

Total Periods: 45

Reference Books:

1. L. L. Freris, 'Wind Energy conversion Systems', Prentice Hall, 1990.
2. S. N. Bhadra, D. Kastha, S. Banerjee, 'Wind Electrical Systems', Oxford University Press, 2010.
3. Ion Boldea, 'Variable speed generators', Taylor & Francis group, 2006.
4. E. W. Golding, 'The generation of Electricity by wind power', Redwood burn Ltd., Trowbridge, 1976.
5. N. Jenkins, 'Wind Energy Technology', John Wiley & Sons, 1997.
6. S. Heir, 'Grid Integration of WECS', Wiley 1998.

Course Outcomes (CO)

CO1	Acquire knowledge on the basic concepts of Wind energy conversion system.
CO2	Understand the mathematical modeling and control of the Wind turbine
CO3	Develop more understanding on the design of Fixed speed system.
CO4	Study about the need of Variable speed system and its modeling.
CO5	Able to learn about Grid integration issues and current practices of wind interconnections with power system.

Course Outcomes	Program Outcomes												PSO			
	a	b	c	d	e	f	g	h	i	j	k	l	1	2	3	4
CO1	3	3	3	3	3	1	3	1	1	1	1	1	3	3	3	1
CO2	3	3	3	3	3	1	3	1	1	1	1	1	3	3	3	1
CO3	3	3	3	3	3	1	3	1	1	1	1	1	3	3	3	1
CO4	3	3	3	3	3	1	3	1	1	1	1	1	3	3	3	1
C05	3	3	3	3	3	1	3	1	1	1	1	1	3	3	3	1

PE1354	ENERGY MANAGEMENT AND AUDITING	L	T	P	C
		3	0	0	3

Objectives

- To study the concepts behind economic analysis and Load management.
- To emphasize the energy management on various electrical equipment and metering.
- To Illustrate the concept of lighting systems and cogeneration.

UNIT – I	INTRODUCTION	9

Need for energy management – Energy basics – Designing and starting an energy management program – Energy accounting – Energy monitoring, targeting and reporting – Energy audit process.

UNIT – II	ENERGY COST AND LOAD MANAGEMENT	9

Important concepts in an economic analysis – Economic models – Time value of money – Utility rate structures – Cost of electricity – Loss evaluation – Load management: Demand control techniques – Utility monitoring and control system – HVAC and energy management – Economic justification.

UNIT – III	ENERGY MANAGEMENT FOR MOTORS, SYSTEMS AND ELECTRICAL EQUIPMENT	9

Systems and equipment – Electric motors – Transformers and reactors – Capacitors and synchronous machines.

UNIT – IV	METERING FOR ENERGY MANAGEMENT	9

Relationships between parameters – Units of measure – Typical cost factors – Utility meters – Timing of meter disc for kilowatt measurement – Demand meters – Paralleling of current transformers – Instrument transformer burdens – Multitasking solid – State meters – Metering location vs. requirements – Metering techniques and practical examples.

UNIT – V	LIGHTING SYSTEMS & COGENERATION	9

Concept of lighting systems – The task and the working space – Light sources – Ballasts – Luminaries – Lighting controls – Optimizing lighting energy – Power factor and effect of harmonics on power quality – Cost analysis techniques – Lighting and energy standards Cogeneration: Forms of cogeneration – Feasibility of cogeneration – Electrical interconnection.

Total Periods:	**45**

Reference Books:

1 Barney L. Capehart, Wayne C. Turner, and William J. Kennedy, 'Guide to Energy Management', Fifth Edition, The Fairmont Press, Inc.,2006
2 Eastop T.D & Croft D.R, 'Energy Efficiency for Engineers and Technologists', Logman Scientific & Technical, 1990.
3 Reay D.A, 'Industrial Energy Conservation', 1st edition, Pergamon Press, 1977.
4 'IEEE Recommended Practice for Energy Management in Industrial and Commercial Facilities', IEEE,1996
5 Amit K. Tyagi, 'Handbook on Energy Audits and Management', TERI, 2003.

Course Outcomes (CO)

CO1	Students will develop the ability to learn about the need for energy management and auditing process.
CO2	Learners will learn about basic concepts of economic analysis and load management.
CO3	Students will understand the energy management on various electrical equipment.
CO4	Students will have knowledge on the concepts of metering and factors influencing cost function.
CO5	Students will be able to learn about the concept of lighting systems, light sources and various forms of cogeneration.

Course Outcomes	**Program Outcomes**												**PSO**			
	a	**b**	**C**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**	**1**	**2**	**3**	**4**
CO1	3	3	3	2	1	1	1	1	1	1	3	3	3	1	3	3
CO2	3	3	3	3	1	1	1	1	1	1	3	3	3	1	3	3
CO3	3	3	3	3	1	1	1	1	1	1	3	3	3	2	3	3
CO4	3	3	3	2	1	1	1	1	1	1	2	3	3	2	3	2
C05	3	3	3	2	1	1	1	1	1	1	3	3	3	2	3	2

PE1355	NON–LINEAR DYNAMICS FOR POWER ELECTRONICS CIRCUIT	L	T	P	C
		3	0	0	3

Objectives

- To understand the non–linear behaviour of power electronic converters
- To understand the techniques for investigation on non – linear behaviour of power electronic converters
- To analyze the non – linear phenomena in DC to DC converters
- To analyze the non – linear phenomena in AC and DC Drives
- To introduce the control techniques for control of non – linear behaviour in power electronic systems

UNIT – I	BASICS OF NON–LINEAR DYNAMICS	9

Basics of Nonlinear Dynamics: System, state and state space model, Vector field – Modelling of Linear, nonlinear and Linearized systems, Attractors, chaos, Poincare map, Dynamics of Discrete time system, Lyapunov Exponent, Bifurcations, Bifurcations of smooth map, Bifurcations in piece wise smooth maps, border crossing and border collision bifurcation.

UNIT – II	TECHNIQUES FOR INVESTIGATION OF NON–LINEAR PHENOMENA	9

Techniques for experimental investigation, Techniques for numerical investigation, Computation of averages under chaos, Computations of spectral peaks, Computation of the bifurcation and analyzing stability.

UNIT – III	NON–LINEAR PHENOMENA IN DC–DC CONVERTERS	9

Border collision in the Current Mode controlled Boost Converter, Bifurcation and chaos in the Voltage controlled Buck Converter with latch, Bifurcation and chaos in the Voltage controlled Buck Converter without latch, Bifurcation and chaos in Cuk Converter. Nonlinear phenomenon in the inverter under tolerance band control.

UNIT – IV	NON–LINEAR PHENOMENA IN DRIVES	9

Nonlinear Phenomenon in Current controlled and voltage–controlled DC Drives, Nonlinear Phenomenon in PMSM Drives.

UNIT – V	CONTROL OF CHAOS	9

Hysteresis control, sliding mode and switching surface control, OGY Method, Pyragas method, Time Delay control. Application of the techniques to the Power electronics circuit and drives.

Total Periods: 45

Reference Books:

1. Steven H Strogatz, Nonlinear Dynamics and Chaos, West view Press, 2001.
2. C.K.TSE Complex Behaviour of Switching Power Converters, CRC Press, 2003.
3. George C. Vargheese, July 2001 Wiley – IEEE Press S Banerjee, Nonlinear Phenomena in Power Electronics, IEEE Press 3.

Course Outcomes (CO)

CO1	Ability to comprehend the non – linear behaviour of power electronic converters
CO2	Ability to understand the techniques for investigation on non – linear behaviour of power electronic converters
CO3	To analyse the non–linear phenomena in DC to DC converters
CO4	To analyse the non–linear phenomena in AC and DC Drives
CO5	Ability to explain the control techniques for control of non–linear behaviour in power electronic systems

Course Outcomes	Program Outcomes										PSO			
	a	b	c	d	e	f	g	h	i	j	1	2	3	4
CO1	3	3	2	3	3	1	1	1	1	1	3	3	3	2
CO2	3	3	2	3	3	1	1	1	1	1	3	3	3	2
CO3	3	3	2	3	3	1	1	1	1	1	3	3	3	2
CO4	3	3	2	3	3	1	1	1	1	1	3	3	3	2
C05	3	3	2	3	3	1	1	1	1	1	3	3	3	2

PE1356	SMART GRID	L	T	P	C
		3	0	0	3

Objectives

- To Study about Smart Grid technologies, different smart meters and advanced metering infrastructure.
- To familiarize the power quality management issues in Smart Grid.
- To familiarize the high–performance computing for Smart Grid application

UNIT – I	INTRODUCTION TO SMART GRID	9

Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, functions, opportunities, challenges and benefits, Difference between conventional & Smart Grid, National and International Initiatives in Smart Grid

UNIT – II	SMART GRID TECHNOLOGIES	9

Technology Drivers, Smart energy resources, Smart substations, Substation Automation, Feeder Automation, Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and control, Distribution systems: DMS, Volt/Var control, Fault Detection, Isolation and service restoration, Outage management, High–Efficiency Distribution Transformers, Phase Shifting Transformers, Plug in Hybrid Electric Vehicles (PHEV)

UNIT – III	SMART METERS AND ADVANCED METERING INFRASTRUCTURE	9

Introduction to Smart Meters, Advanced Metering infrastructure (AMI) drivers and benefits, AMI protocols, standards and initiatives, AMI needs in the smart grid, Phasor Measurement Unit(PMU), Intelligent Electronic Devices (IED) & their application for monitoring & protection

UNIT – IV	POWER QUALITY MANAGEMENT INSMART GRID	9

Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit

UNIT – V	HIGH PERFORMANCE COMPUTING FOR SMART GRID APPLICATIONS	9

Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), Broadband over Power line (BPL), IP based Protocols, Basics of Web Service and CLOUD Computing to make Smart Grids smarter, Cyber Security for Smart Grid

Total Periods:	**45**

Text Books:

1. Stuart Borlase 'Smart Grid: Infrastructure, Technology and Solutions', CRC Press, 2012.
2. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, 'Smart Grid: Technology and Applications', Wiley, 2012.

Reference Books:

1. Vehbi C. Güngör, Dilan Sahin, Taskin Kocak, Salih Ergüt, Concettina Buccella, Carlo Cecati and Gerhard P. Hancke, 'Smart Grid Technologies: Communication Technologies and Standards', IEEE Transactions on Industrial Informatics, Vol. 7, No. 4, November 2011.
2. Xi Fang, Satyajayant Misra, Guoliang Xue, and Dejun Yang, 'Smart Grid – The New and Improved Power Grid: A Survey', IEEE Transaction on Smart Grids, Vol. 14, 2012.

Course Outcomes (CO):

CO1	Learners will develop more understanding on the concepts of Smart Grid and its present developments.
CO2	Learners will study about different Smart Grid technologies.
CO3	Learners will acquire knowledge about different smart meters and advanced metering infrastructure.
CO4	Learners will have knowledge on power quality management in Smart Grids
CO5	Learners will develop more understanding on LAN, WAN and Cloud Computing for Smart Grid applications.

Course Outcomes	**Program Outcomes**												**PSO**			
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**	**1**	**2**	**3**	**4**
CO1	3	1	2	1	1	2	2	1	1	1	1	1	3	1	1	1
CO2	3	1	2	1	1	2	2	1	1	1	1	1	3	1	1	1
CO3	3	1	2	1	1	2	2	1	1	1	1	1	3	1	1	1
CO4	3	1	2	1	1	2	2	1	1	1	1	1	3	1	1	1
C05	3	1	2	1	1	2	2	1	1	1	1	1	3	1	1	1

PE1357	POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS	L	T	P	C
		3	0	0	3

Objectives

- To provide knowledge about the stand alone and grid connected renewable energy systems.
- To equip with required skills to derive the criteria for the design of power converters for renewable energy applications.
- To analyse and comprehend the various operating modes of wind electrical generators and solar energy systems.
- To design different power converters namely AC to DC, DC to DC and AC to AC converters for renewable energy systems.
- To develop maximum power point tracking algorithms

UNIT – I	INTRODUCTION	9

Environmental aspects of electric energy conversion: Impacts of renewable energy generation on environment (cost–GHG Emission) – Qualitative study of different renewable energy resources ocean, Biomass, Hydrogen energy systems: Operating principles and characteristics of: Solar PV, Fuel cells, Wind electrical systems – Control strategy, Operating area.

UNIT – II	ELECTRICAL MACHINES FOR RENEWABLE ENERGY CONVERSION	9

Review of reference theory fundamentals – Principle of operation and analysis: IG, PMSG, SCIG and DFIG.

UNIT – III	POWER ELECTRONICS FOR SOLAR	9

Block diagram of Solar Photovoltaic system: Line commutated converters (inversion–mode) – Boost and Buck–Boost Converters – Selection of inverter, Battery sizing, Array sizing – Standalone PV systems – Grid tied and Grid interactive inverters – Grid connection issues.

UNIT – IV	POWER ELECTRONICS FOR WIND	9

Three phase AC voltage controllers – AC–DC–AC converters: Uncontrolled rectifiers, PWM Inverters, Matrix converters – Standalone operation of fixed and variable speed wind energy conversion systems – Grid connection Issues – Grid integrated PMSG and SCIG Based WECS.

UNIT – V	HYBRID RENEWABLE ENERGY SYSTEMS	9

Need for Hybrid Systems – Range and type of Hybrid Systems – Case studies of Wind – PV– Maximum Power Point Tracking (MPPT).

Total Periods:	45

Text Books:

1 S. N. Bhadra, D. Kastha, & S. Banerjee 'Wind Electrical Systems', Oxford University Press, 2009.
2 M. H. Rashid, 'Power Electronics Hand book', Academic press, 2001.
3 G.D. Rai, 'Non–Conventional Energy Sources', Khanna publishers, 2004.
4 G.D. Rai, 'Solar Energy Utilization', Khanna publishes, 1993.

Reference Books:

1 Gray, L. Johnson, 'Wind energy system', Prentice Hall linc, 2006.
2 B. H. Khan, 'Non–conventional Energy sources', Tata McGraw Hill Publishing Company, 2006.
3 P.S. Bimbhra, 'Power Electronics', Khanna Publishers, 5th Edition, 2012.
4 Fang Lin Luo, Hong Ye, 'Renewable Energy Systems', Taylor & Francis Group, 2013.
5 R. Seyezhai and R. Ramaprabha, 'Power Electronics for Renewable Energy Systems', Scitech Publications, 2015.

Course Outcomes (CO)

CO1	Discuss and analyze the various types of renewable energy sources
CO2	Analyze the performance of IG, PMSG, SCIG AND DFIG
CO3	Design different power converters namely AC to DC, DC to DC and AC to AC converters for renewable energy sources
CO4	Analyze various operating modes of wind electrical generators and solar energy systems
CO5	Develop maximum power point tracking algorithms

Course Outcomes	Program Outcomes												PSO			
	a	b	c	d	e	f	g	h	i	j	k	l	1	2	3	4
CO1	3	3	3	1	2	1	1	2	1	1	3	2	1	1	3	3
CO2	3	3	3	1	2	1	1	2	1	1	3	2	1	1	3	3
CO3	3	3	3	1	2	1	1	2	1	1	3	2	1	1	3	3
CO4	3	3	3	1	2	1	1	2	1	1	3	2	1	1	3	3
C05	3	3	3	1	2	1	1	2	1	1	3	2	1	1	3	3

PE1358	ROBOTICS AND CONTROL	L	T	P	C
		3	0	0	3

Objectives

- To introduce robot terminologies and robotic sensors
- To educate direct and inverse kinematic relations
- To educate on formulation of manipulator Jacobians and introduce path planning techniques
- To educate on robot dynamics
- To introduce robot control techniques

UNIT – I	INTRODUCTION AND TERMINOLOGIES	9

Definition – Classification – History – Robot's components – Degrees of freedom – Robot joints – Coordinates – Reference frames – Workspace – Robot languages – Actuators – Sensors: Position, Velocity, Acceleration, Torque, Tactile, Touch, Proximity and range sensors – Vision system – Social issues.

UNIT – II	KINEMATICS	9

Mechanism – Matrix representation – Homogenous transformation – DH representation – Inverse kinematics solution and programming – Degeneracy and Dexterity

UNIT – III	DIFFERENTIAL MOTION AND PATH PLANNING	9

Jacobian – Differential motion of frames – Interpretation – Calculation of Jacobian – Inverse Jacobian – Robot Path planning.

UNIT – IV	DYNAMIC MODELLING	9

Lagrangian mechanics – Two–DOF manipulator – Lagrange – Euler formulation – Newton – Euler formulation – Inverse dynamics

UNIT – V	ROBOT CONTROL SYSTEM	9

Linear control schemes – Joint actuators – Decentralized PID control – Computed torque control – Force control – Hybrid position force control – Impedance / Torque control

Total Periods: 45

Text Books:

1. R.K. Mittal and I J Nagrath, 'Robotics and Control', Tata MacGraw Hill, Fourth edition.
2. Saeed B. Niku, 'Introduction to Robotics', Pearson Education, 2002.

Reference Books:

1. K. S. Fu, R.C. Gonzalez and C.S.G. Lee, 'Robotics: Control, Sensing, Vision and Intelligence' McGraw Hill Education India, 1986.
2. R. D. Klafter, TA Chmielewski and Michael Negin, 'Robotic Engineering, An Integrated approach', Prentice Hall of India, 2003.
3. R.D. Klafter, T. A. Chmielewski and M. Negin, 'Robotic Engineering – An Integrated Approach', Prentice Hall, 2003.
4. M. P. Groover, 'Industrial Robotics – Technology Programming and Applications', McGraw Hill, 2001.

Course Outcomes (CO)

CO1	Ability to understand the components and basic terminology of Robotics
CO2	Ability to understand the basics of kinematics relations
CO3	Ability to model the motion of Robots and analyze the workspace and trajectory panning of robots
CO4	Ability to develop application–based Robots
CO5	Ability to formulate models for the control of mobile robots in various industrial applications

Course Outcomes	**Program Outcomes**												**PSO**			
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**	**1**	**2**	**3**	**4**
CO1	3	2	2	1	1	1	1	1	1	1	1	1	3	1	1	1
CO2	3	2	2	1	1	1	1	1	1	1	1	1	3	1	1	1
CO3	3	2	2	2	1	1	1	1	1	1	1	1	3	3	2	1
CO4	3	2	2	2	1	1	1	1	1	1	1	1	3	3	2	1
CO5	3	1	1	1	1	1	1	1	1	1	1	1	2	3	1	1

PE1359	NON–LINEAR CONTROL	L	T	P	C
		3	0	0	3

Objectives

- To impart knowledge on phase plane analysis of non–linear systems.
- To impart knowledge on Describing function–based approach to non–linear systems.
- To educate on stability analysis of systems using Lyapunov's theory.
- To introduce the concept of sliding mode control.

UNIT – I	PHASE PLANE ANALYSIS	9

Concepts of phase plane analysis – Phase portraits – Singular points – Symmetry in phase plane portraits – Constructing Phase Portraits – Phase plane Analysis of Linear and Nonlinear Systems – Existence of Limit Cycles; simulation of phase portraits in MATLAB.

UNIT – II	DESCRIBING FUNCTION	9

Describing Function Fundamentals – Definitions – Assumptions – Computing Describing Functions; Common Non-linearities and its Describing Functions – Nyquist Criterion and its Extension – Existence of Limit Cycles – Stability of limit Cycles; Simulation of limit cycles in MATLAB.

UNIT – III	LYAPUNOV THEORY	9

Nonlinear Systems and Equilibrium Points – Concepts of Stability – Linearization and Local Stability; Lyapunov's Direct Method – Positive definite Functions and Lyapunov Functions; Equilibrium Point Theorems – Invariant Set Theorems – LTI System Analysis based on Lyapunov's Direct Method; Krasovski's Method – Variable Gradient Method – Physically – Control Design based on Lyapunov's Direct Method.

UNIT – IV	FEEDBACK LINEARIZATION	9

Feedback Linearization and the Canonical Form–Mathematical Tools – Input–State Linearization of SISO Systems – input–Output Linearization of SISO Systems; Generating a Linear Input – Output Relation – Normal Forms – The Zero–Dynamics – Stabilization and Tracking – Inverse Dynamics and Non-Minimum -Phase Systems; Feedback Linearization of MIMO Systems Zero–Dynamics and Control Design; Simulation of tracking problems in MATLAB.

UNIT – V	SLIDING MODE CONTROL	9

Sliding Surfaces – Continuous approximations of Switching Control laws – The Modelling / Performance Trade – Offs – MIMO Systems; Simulation of sliding mode controller in MATLAB.

Total Periods:	**45**

Text Books:

1 J. A. E. Slotine and W. Li, Applied Nonlinear control, PHI, Taiwan, 2005.
2 K. P. Mohandas, Modern Control Engineering, Sanguine, India, 2008.
3 Hasan Khalil, 'Nonlinear control', Pearson Education Limited, 2015.

Reference Books:

1 S H Zak, 'Systems and control', Oxford University Press, 2003.
2 Torkel Glad and Lennart Ljung, 'Control Theory – Multivariable and Nonlinear Methods', CRC Press, 2018.
3 G. J. Thaler, 'Automatic control systems', Jaico publishers, 2006.

Course Outcomes (CO)

CO1	Ability to understand the phase plane analysis of non–linear systems.
CO2	Ability to understand the function–based approach to non–linear systems.
CO3	Ability to understand the stability analysis of systems using Lyapunov's theory.
CO4	Ability to understand about feedback linearization.
CO5	Ability to introduce the concept of sliding mode control.

Course Outcomes	Program Outcomes												PSO			
	a	b	c	d	e	f	g	h	i	j	k	l	1	2	3	4
CO1	3	3	3	1	2	1	1	2	1	1	3	2	1	1	3	3
CO2	3	3	3	1	2	1	1	2	1	1	3	2	1	1	3	3
CO3	3	3	3	1	2	1	1	2	1	1	3	2	1	1	3	3
CO4	3	3	3	1	2	1	1	2	1	1	3	2	1	1	3	3
C05	3	3	3	1	2	1	1	2	1	1	3	2	1	1	3	3

OPEN ELECTIVE COURSES [OEC]

OCP 101	Business Data Analytics	L	T	P	C
		3	0	0	3

Objectives

- To understand the basics of business analytics and its life cycle.
- To gain knowledge about fundamental business analytics.
- To learn modeling for uncertainty and statistical inference.
- To understand analytics using Hadoop and Map Reduce frameworks.
- To acquire insight on other analytical frameworks.

UNIT – I	OVERVIEW OF BUSINESS ANALYTICS	9

Introduction – Drivers for Business Analytics – Applications of Business Analytics: Marketing and Sales, Human Resource, Healthcare, Product Design, Service Design, Customer Service and Support – Skills Required for a Business Analyst – Framework for Business Analytics Life Cycle for Business Analytics Process.

Suggested Activities:

- Case studies on applications involving business analytics.
- Converting real–time decision–making problems into hypothesis.
- Group discussion on entrepreneurial opportunities in Business Analytics.

Suggested Evaluation Methods:

- Assignment on business scenario and business analytical life cycle process.
- Group presentation on big data applications with societal need.
- Quiz on case studies.

UNIT – II	ESSENTIALS OF BUSINESS ANALYTICS	9

Descriptive Statistics – Using Data – Types of Data – Data Distribution Metrics: Frequency, Mean, Median, Mode, Range, Variance, Standard Deviation, Percentile, Quartile, Z–Score, Covariance, Correlation – Data Visualization: Tables, Charts, Line Charts, Bar and Column Chart, Bubble Chart, Heat Map – Data Dashboards.

Suggested Activities:

- Solve numerical problems on basic statistics.
- Explore chart wizard in MS Excel Case using sample real time data for data visualization.
- Use R tool for data visualization.

Suggested Evaluation Methods:

- Assignment on descriptive analytics using benchmark data.
- Quiz on data visualization for univariate, bivariate data.

UNIT – III	MODELING UNCERTAINTY AND STATISTICAL INFERENCE	9

Modeling Uncertainty: Events and Probabilities – Conditional Probability – Random Variables – Discrete Probability Distributions – Continuous Probability Distribution – Statistical Inference: Data Sampling – Selecting a Sample – Point Estimation – Sampling Distributions – Interval Estimation – Hypothesis Testing.

Suggested Activities:

- Solving numerical problems in sampling, probability, probability distributions and
- Hypothesis testing.
- Converting real–time decision–making problems into hypothesis.

Suggested Evaluation Methods:

- Assignments on hypothesis testing.
- Group presentation on real time applications involving data sampling and hypothesis testing.
- Quizzes on topics like sampling and probability.

UNIT – IV	ANALYTICS USING HADOOP AND MAPREDUCE FRAMEWORK	9

Introducing Hadoop – RDBMS versus Hadoop – Hadoop Overview – HDFS (Hadoop Distributed File System) – Processing Data with Hadoop – Introduction to MapReduce – Features of MapReduce – Algorithms Using Map–Reduce: Matrix–Vector Multiplication, Relational Algebra Operations, Grouping and Aggregation – Extensions to MapReduce.

Suggested Activities:

- Practical – Install and configure Hadoop.
- Practical – Use web–based tools to monitor Hadoop setup.
- Practical – Design and develop MapReduce tasks for word count, searching involving text corpus etc.

Suggested Evaluation Methods:

- Evaluation of the practical implementations.
- Quizzes on topics like HDFS and extensions to MapReduce.

UNIT – V	OTHER DATA ANALYTICAL FRAMEWORKS	9

Overview of Application development Languages for Hadoop – PigLatin – Hive – Hive Query Language (HQL) – Introduction to Pentaho, JAQL – Introduction to Apache: Sqoop, Drill and Spark, Cloudera Impala – Introduction to NoSQL Databases – Hbase and MongoDB.

Suggested Activities:

- Practical – Installation of NoSQL database like MongoDB.
- Practical – Demonstration on Sharding in MongoDB.
- Practical – Install and run Pig
- Practical – Write PigLatin scripts to sort, group, join, project, and filter data.
- Design and develop algorithms to be executed in MapReduce involving numerical methods for analytics.

Suggested Evaluation Methods:

- Mini Project (Group) – Real time data collection, saving in NoSQL, implement analytical techniques using Map–Reduce Tasks and Result Projection

Total Periods: 45

Reference Books:

1. Vignesh Prajapati, 'Big Data Analytics with R and Hadoop', Packt Publishing, 2013.
2. Umesh R Hodeghatta, Umesha Nayak, 'Business Analytics Using R – A Practical Approach', A press, 2017.
3. Anand Rajaraman, Jeffrey David Ullman, 'Mining of Massive Datasets', Cambridge University Press, 2012.
4. Jeffrey D. Camm, James J. Cochran, Michael J. Fry, Jeffrey W. Ohlmann, David R. Anderson, 'Essentials of Business Analytics', Cengage Learning, second Edition, 2016.
5. U. Dinesh Kumar, 'Business Analytics: The Science of Data–Driven Decision Making', Wiley, 2017.
6. A. Ohri, 'R for Business Analytics', Springer, 2012
7. Rui Miguel Forte, 'Mastering Predictive Analytics with R', Packt Publication, 2015.

Course Outcomes (CO)

CO1	Identify the real–world business problems and model with analytical solutions.
CO2	Solve analytical problem with relevant mathematics background knowledge.
CO3	Convert any real–world decision–making problem to hypothesis and apply suitable statistical testing.
CO4	Write and demonstrate simple applications involving analytics using Hadoop and MapReduce
CO5	Use open–source frameworks for modeling and storing data and apply suitable visualization technique using R for visualizing voluminous data

Course Outcomes	Program Outcomes												PSO			
	a	b	c	d	e	f	g	h	i	j	k	l	1	2	3	4
CO1	3	3	3	3	2	2	1	1	2	1	2	1	2	2	2	1
CO2	3	3	3	3	2	2	1	1	2	1	2	1	2	2	2	1
CO3	3	3	3	3	2	2	1	1	2	1	2	1	2	2	2	1
CO4	3	3	3	3	2	2	1	1	2	1	2	1	2	2	2	1
C05	3	3	3	3	3	2	1	1	2	1	2	1	2	2	2	1

OMF 101	INDUSTRIAL SAFETY	L	T	P	C
		3	0	0	3

Objectives

- Summarize basics of industrial safety
- Describe fundamentals of maintenance engineering
- Explain wear and corrosion
- Illustrate fault tracing
- Identify preventive and periodic maintenance

UNIT – I	INTRODUCTION	9

Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps / procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

UNIT – II	FUNDAMENTALS OF MAINTENANCE ENGINEERING	9

Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

UNIT – III	WEAR AND CORROSION AND THEIR PREVENTION	9

Wear– types, causes, effects, wear reduction methods, lubricants–types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

UNIT – IV	FAULT TRACING	9

Fault tracing–concept and importance, decision tree concept, need and applications, sequence of fault–finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, i. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

UNIT – V	PERIODIC AND PREVENTIVE MAINTENANCE	9

Periodic inspection–concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: i. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

Total Periods: 45

Reference Books:

1. Audels, 'Pump–hydraulic Compressors', Mcgrew Hill Publication, 1978.
2. H. P. Garg, 'Maintenance Engineering', S. Chand and Company, 1987.
3. Hans F. Winterkorn, 'Foundation Engineering Handbook', Chapman & Hall London, 2013.
4. Higgins & Morrow,' Maintenance Engineering Handbook', Eighth Edition, 2008.

Course Outcomes (CO)

CO1	Ability to summarize basics of industrial safety
CO2	Ability to describe fundamentals of maintenance engineering
CO3	Ability to explain wear and corrosion
CO4	Ability to illustrate fault tracing
CO5	Ability to identify preventive and periodic maintenance

Course Outcomes	Program Outcomes												PSO			
	a	b	c	d	e	f	g	h	i	j	k	l	1	2	3	4
CO1	3	2	2	2	1	2	2	1	1	1	1	2	3	2	2	1
CO2	3	2	2	2	1	2	2	1	2	1	1	2	3	2	2	1
CO3	3	3	3	2	1	2	2	1	1	1	1	2	3	2	2	1
CO4	3	3	3	2	1	2	2	1	2	1	1	2	3	2	2	1
C05	3	3	3	2	1	2	2	1	2	1	1	2	3	2	2	1

OMB 103	COST MANAGEMENT OF ENGINEERING PROJECTS	L	T	P	C
		3	0	0	3

Objectives

- Summarize the costing concepts and their role in decision making
- Infer the project management concepts and their various aspects in selection
- Interpret costing concepts with project execution
- Develop knowledge of costing techniques in service sector and various budgetary control techniques
- Illustrate with quantitative techniques in cost management

UNIT – I	INTRODUCTION TO COSTING CONCEPTS	9

Objectives of a Costing System; Cost concepts in decision–making; Relevant cost, Differential cost, Incremental cost and Opportunity cost; Creation of a Database for operational control.

UNIT – II	INTRODUCTION TO PROJECT MANAGEMENT	9

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities, Detailed Engineering activities, Pre project execution main clearances and documents, Project team: Role of each member, Importance Project site: Data required with significance, Project contracts.

UNIT – III	PROJECT EXECUTION AND COSTING CONCEPTS	9

Project execution Project cost control, Bar charts and Network diagram, Project commissioning: mechanical and process, Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break–even Analysis, Cost–Volume–Profit Analysis, Various decision–making problems, Pricing strategies: Pareto Analysis, Target costing, Life Cycle Costing.

UNIT – IV	COSTING OF SERVICE SECTOR AND BUDGETERY CONTROL	9

Just–in–time approach, Material Requirement Planning, Enterprise Resource Planning, Activity– Based Cost Management, Bench Marking; Balanced Score Card and Value–Chain Analysis, Budgetary Control: Flexible Budgets; Performance budgets; Zero–based budgets.

UNIT – V	QUANTITATIVE TECHNIQUES FOR COST MANAGEMENT	9

Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Learning Curve Theory.

Total Periods:	**45**

Reference Books:

1. Ashish K. Bhattacharya, 'Principles & Practices of Cost Accounting' A. H. Wheeler publisher, 1991.
2. Charles T. Horngren and George Foster, 'Advanced Management Accounting', Pearson Prentice Hall, 1988.
3. Charles T. Horngren et. Al. 'Cost Accounting A Managerial Emphasis', Prentice Hall of India, New Delhi, 2011.
4. Robert S Kaplan and Anthony A. Alkinson, 'Management & Cost Accounting', Pearson Prentice Hall, 2003.
5. N. D. Vohra, 'Quantitative Techniques in Management', Tata McGraw Hill Book Co. Ltd, 2007.

Course Outcomes (CO)

CO1	Understand the costing concepts and their role in decision making
CO2	Understand the project management concepts and their various aspects in selection
CO3	Interpret costing concepts with project execution
CO4	Gain knowledge of costing techniques in service sector and various budgetary control techniques
CO5	Become familiar with quantitative techniques in cost management

Course Outcomes	Program Outcomes												PSO			
	a	b	c	d	e	f	g	h	i	J	k	l	1	2	3	4
CO1	3	3	3	2	3	2	2	3	3	1	3	3	2	2	2	1
CO2	3	3	3	2	3	2	1	2	3	1	3	3	2	2	2	1
CO3	3	3	3	2	3	3	1	2	2	1	3	3	2	2	1	1
CO4	3	3	3	2	3	2	3	1	2	1	3	3	2	2	1	1
C05	3	3	3	2	3	3	3	1	2	1	3	3	2	2	1	1

OMF 102	COMPOSITE MATERIALS	L	T	P	C
		3	0	0	3

Objectives

- Summarize the characteristics of composite materials and effect of reinforcement in composite materials.
- Identify the various reinforcements used in composite materials.
- Compare the manufacturing process of metal matrix composites.
- Understand the manufacturing processes of polymer matrix composites.
- Analyze the strength of composite materials.

UNIT – I	INTRODUCTION	9

Definition – Classification and characteristics of Composite materials – Advantages and application of composites – Functional requirements of reinforcement and matrix – Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

UNIT – II	REINFORCEMENTS	9

Preparation–layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers – Properties and applications of whiskers, particle reinforcements – Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures – Isostrain and Isostress conditions.

UNIT – III	MANUFACTURING OF METAL MATRIX COMPOSITES	9

Casting – Solid State diffusion technique – Cladding – Hot Isostatic pressing – Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving – Properties and applications.

UNIT – IV	MANUFACTURING OF POLYMER MATRIX COMPOSITES	9

Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding – Properties and applications.

UNIT – V	STRENGTH	9

Laminar Failure Criteria–strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure–insight strength; Laminate strength–ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

Total Periods:	**45**

Reference Books:

1. R. W. Cahn, 'Material Science and Technology', Vol. 13, Composites, VCH, West Germany.
2. Callister, W.D Jr., Adapted by Balasubramaniam R, 'Materials Science and Engineering, An introduction', John Wiley & Sons, NY, Indian edition, 2007.
3. K. K. Chawla, 'Composite Materials', 2013.
4. G. Lubin, Hand Book of Composite Materials, 2013.

Course Outcomes (CO)

CO1	Know the characteristics of composite materials and effect of reinforcement in composite materials.
CO2	Know the various reinforcements used in composite materials.
CO3	Understand the manufacturing processes of metal matrix composites.
CO4	Understand the manufacturing processes of polymer matrix composites.
CO5	Analyze the strength of composite materials.

Course Outcomes	**Program Outcomes**												**PSO**			
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**	**1**	**2**	**3**	**4**
CO1	3	3	3	3	2	2	2	1	1	1	2	2	2	2	2	1
CO2	3	3	3	3	3	2	2	1	1	1	3	2	2	2	2	1
CO3	3	2	3	3	3	2	3	1	1	1	3	1	2	2	1	1
CO4	3	2	3	3	3	2	3	1	1	1	3	2	2	2	1	1
C05	3	2	2	3	3	2	3	1	1	1	2	2	2	2	1	1

OCH 105	WASTE TO ENERGY	L	T	P	C
		3	0	0	3

Objectives

- Interpret the various types of wastes from which energy can be generated
- Develop knowledge on biomass pyrolysis process and its applications
- Develop knowledge on various types of biomass gasifiers and their operations
- Invent knowledge on biomass combustors and its applications on generating energy
- Summarize the principles of bio–energy systems and their features

UNIT – I	INTRODUCTION TO EXTRACTION OF ENERGY FROM WASTE	9

Classification of waste as fuel – Agro based, Forest residue, Industrial waste – MSW – Conversion devices – Incinerators, gasifiers, digestors

UNIT – II	BIOMASS PYROLYSIS	9

Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods – Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

UNIT – III	BIOMASS GASIFICATION	9

Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

UNIT – IV	BIOMASS COMBUSTION	9

Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation – Operation of all the above biomass combustors.

UNIT – V	BIO ENERGY	9

Properties of biogas (Calorific value and composition), Biogas plant technology and status – Bio energy system – Design and constructional features – Biomass resources and their classification – Biomass conversion processes – Thermo chemical conversion – Direct combustion – biomass gasification – pyrolysis and liquefaction – biochemical conversion – anaerobic digestion – Types of biogas Plants – Applications – Alcohol production from biomass – Bio diesel production – Urban waste to energy conversion – Biomass energy programme in India.

Total Periods:	**45**

Reference Books:

1. K. C. Khandelwal and S. S. Mahdi, 'Biogas Technology – A Practical Hand Book – Vol. I & II', Tata McGraw Hill Publishing Co. Ltd., 1983.
2. C. Y. WereKo–Brobby and E. B. Hagan, 'Biomass Conversion and Technology', John Wiley & Sons, 1996.
3. D. S. Challal, 'Food, Feed and Fuel from Biomass', IBH Publishing Co. Pvt. Ltd., 1991.
4. Ashok V. Desai, 'Non–Conventional Energy', Wiley Eastern Ltd., 1990.

Course Outcomes (CO)

CO1	Understand the various types of wastes from which energy can be generated
CO2	Gain knowledge on biomass pyrolysis process and its applications
CO3	Develop knowledge on various types of biomass gasifiers and their operations
CO4	Gain knowledge on biomass combustors and its applications on generating energy
CO5	Understand the principles of bio–energy systems and their features

Course Outcomes	Program Outcomes												PSO			
	a	b	c	d	e	f	g	h	i	j	k	l	1	2	3	4
CO1	3	2	3	2	2	2	2	1	1	1	2	3	3	2	1	1
CO2	3	2	3	2	2	2	2	1	1	1	2	3	2	2	1	1
CO3	3	3	3	2	3	2	3	1	1	1	2	3	2	2	1	1
CO4	3	3	3	2	3	2	2	1	1	1	2	3	3	2	1	1
C05	3	3	3	2	3	2	2	1	1	1	2	3	2	2	1	1

AUDIT COURSES

AX1001	ENGLISH FOR RESEARCH PAPER WRITING	L	T	P	C
		2	0	0	0

Objectives

- Teach how to improve writing skills and level of readability.
- Tell about what to write in each section.
- Summarize the skills needed when writing a title.
- Infer the skills needed when writing the conclusion.
- Ensure the quality of paper at very first–time submission.

UNIT – I	INTRODUCTION TO RESEARCH PAPER WRITING	6

Planning and Preparation, Word Order, breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness.

UNIT – II	PRESENTATION SKILLS	6

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Introduction.

UNIT – III	TITLE WRITING SKILLS	6

Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.

UNIT – IV	RESULT WRITING SKILLS	6

Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion and skills are needed when writing the Conclusions.

UNIT – V	VERIFICATION SKILLS	6

Useful phrases, checking Plagiarism, how to ensure paper is as good as it could possibly be the first–time submission.

Total Periods: 30

Reference Books:

1. Adrian Wallwork, 'English for Writing Research Papers', Springer New York Dordrecht Heidelberg London, 2011.
2. R. Day, 'How to Write and Publish a Scientific Paper', Cambridge University Press, 2006.
3. R. Goldbort, 'Writing for Science', Yale University Press, 2006.
4. N. Highman, 'Handbook of Writing for the Mathematical Sciences', SIAM, Highman's book, 1998.

Course Outcomes (CO)

CO1	Understand that how to improve your writing skills and level of readability
CO2	Learn about what to write in each section
CO3	Understand the skills needed when writing a Title
CO4	Understand the skills needed when writing the Conclusion
CO5	Ensure the good quality of paper at very first–time submission

AX1002	DISASTER MANAGEMENT	L	T	P	C
		2	0	0	0

Objectives

- Summarize basics of disaster
- Explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.
- Illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
- Describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
- Develop the strengths and weaknesses of disaster management approaches.

UNIT – I	INTRODUCTION	6

Disaster: Definition, Factors and Significance; Difference between Hazard and Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.

UNIT – II	REPERCUSSIONS OF DISASTERS AND HAZARDS	6

Economic Damage, Loss of Human and Animal Life, Destruction of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts and Famines, Landslides And Avalanches, Man–made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks of Disease And Epidemics, War And Conflicts.

UNIT – III	DISASTER PRONE AREAS IN INDIA	6

Study of Seismic Zones; Areas Prone to Floods and Droughts, Landslides And Avalanches; Areas Prone To Cyclonic and Coastal Hazards with Special Reference to Tsunami; Post–Disaster Diseases and Epidemics

UNIT – IV	DISASTER PREPAREDNESS AND MANAGEMENT	6

Preparedness: Monitoring of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological and Other Agencies, Media Reports: Governmental and Community Preparedness.

UNIT – V	RISK ASSESSMENT	6

Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co–Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival

Total Periods:	30

Reference Books:

1. S. L. Goel, 'Disaster Administration and Management Text and Case Studies', Deep & Deep Publication, Pvt. Ltd., New Delhi, 2009.
2. Nishitha Rai, A. K. Singh, 'Disaster Management in India: Perspectives, issues and strategies', New Royal book Company, 2007.
3. Sahni, Pardeep, et. Al., 'Disaster Mitigation Experiences and Reflections', Prentice Hall of India, New Delhi, 2001.

Course Outcomes (CO)

CO1	Ability to summarize basics of disaster
CO2	Ability to explain critical understanding of key concepts in disaster risk reduction and humanitarian response
CO3	Ability to illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
CO4	Ability to describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
CO5	Ability to develop the strengths and weaknesses of disaster management approaches

Course Outcomes	Program Outcomes												PSO				
	a	b	C	d	e	f	g	h	i	j	k	l	1	2	3	4	5
CO1	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
CO2	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
CO3	3	3	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1
CO4	3	3	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1
C05	3	3	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1

AX1003	SANSKRIT FOR TECHNICAL KNOWLEDGE	L	T	P	C
		2	0	0	0

Objectives

- To get a working knowledge in illustrious Sanskrit, the scientific language in the world
- Learning of Sanskrit to improve brain functioning
- Learning of Sanskrit to develop the logic in mathematics, science & other subjects, enhancing the memory power
- The engineering scholars equipped with Sanskrit will be able to explore the huge knowledge from ancient literature

UNIT – I	**ALPHABETS**	**6**
Alphabets in Sanskrit.		
UNIT – II	**TENSES AND SENTENCES**	**6**
Past / Present / Future Tense – Simple Sentences.		
UNIT – III	**ORDER AND ROOTS**	**6**
Order – Introduction of roots.		
UNIT – IV	**SANSKRIT LITERATURE**	**6**
Technical information about Sanskrit Literature.		
UNIT – V	**TECHNICAL CONCEPTS OF ENGINEERING**	**6**
Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics.		
	Total Periods:	**30**

Reference Books:

1. "Abhyaspustakam" – Dr. Vishwas, Samskrita-Bharti Publication, New Delhi
2. "Teach Yourself Sanskrit" Prathama Deeksha-Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. "India's Glorious Scientific Tradition" Suresh Soni, Ocean books (P) Ltd., New Delhi, 2017.

Course Outcomes (CO)

CO1	Understanding basic Sanskrit language.
CO2	Write sentences.
CO3	Know the order and roots of Sanskrit.
CO4	Know about technical information about Sanskrit literature.
CO5	Understand the technical concepts of Engineering.

Course Outcomes	Program Outcomes												PSO				
	a	b	C	d	e	f	g	h	i	j	k	l	1	2	3	4	5
CO1	1	1	1	1	1	1	1	1	1	3	1	3	1	1	1	1	1
CO2	1	1	1	1	1	1	1	1	1	3	1	3	1	1	1	1	1
CO3	1	1	1	1	1	1	1	1	1	3	1	3	1	1	1	1	1
CO4	1	1	1	1	1	1	1	1	1	3	1	3	1	1	1	1	1
C05	1	1	1	1	1	1	1	1	1	3	1	3	1	1	1	1	1

AX1004	**VALUE EDUCATION**	**L**	**T**	**P**	**C**
		2	**0**	**0**	**0**

Objectives

- Understand value of education and self–development
- Imbibe good values in students
- Let the students know about the importance of character

UNIT – I		**6**

Values and self–development–Social values and individual attitudes. Work ethics, Indian vision of humanism. Moral and non–moral valuation. Standards and principles. Value judgements

UNIT – II		**6**

Importance of cultivation of values. Sense of duty. Devotion, Self–reliance. Confidence, Concentration. Truthfulness, Cleanliness. Honesty, Humanity. Power of faith, National Unity. Patriotism. Love for nature, Discipline.

UNIT – III		**6**

Personality and Behavior Development–Soul and Scientific attitude. Positive Thinking. Integrity and discipline. Punctuality, Love and Kindness. Avoid fault Thinking. Free from anger, Dignity of labour. Universal brother hood and religious tolerance. True friendship. Happiness vs suffering, love for truth. Aware of self–destructive habits. Association and Cooperation. Doing best for saving nature.

UNIT – IV		**6**

Character and Competence – Holy books vs Blind faith. Self–management and good health. Science of reincarnation. Equality, Nonviolence, Humility, Role of Women. All religions and same message. Mind your Mind, Self–control. Honesty, Studying effectively.

Total Periods:	**30**

Reference Books:

1. Chakroborty, S.K. 'Values and Ethics for organizations Theory and practice', Oxford University Press, New Delhi.

Course Outcomes (CO)

CO1	Knowledge of self–development
CO2	Learn the importance of Human values
CO3	Developing the overall personality.
CO4	Developing the competence and self–control

Course Outcomes	Program Outcomes												PSO				
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**	**1**	**2**	**3**	**4**	**5**
CO1	1	1	1	1	1	1	1	1	2	3	1	1	1	1	1	1	1
CO2	1	1	1	1	1	1	1	1	2	3	1	1	1	1	1	1	1
CO3	1	1	1	1	1	1	1	1	2	3	1	1	1	1	1	1	1
CO4	1	1	1	1	1	1	1	1	2	3	1	1	1	1	1	1	1

AX1005	CONSTITUTION OF INDIA	L	T	P	C
		2	0	0	0

Objectives

- Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
- To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional
- Role and entitlement to civil and economic rights as well as the emergence nation hood in the early years of Indian nationalism.
- To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917and its impact on the initial drafting of the Indian Constitution.

UNIT – I	HISTORY OF MAKING OF THE INDIAN CONSTITUTION	5

History, Drafting Committee, (Composition & Working)

UNIT – II	PHILOSOPHY OF THE INDIAN CONSTITUTION	5

Preamble, Salient Features

UNIT – III	CONTOURS OF CONSTITUTIONAL RIGHTS AND DUTIES	5

Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.

UNIT – IV	ORGANS OF GOVERNANCE	5

Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions.

UNIT – V	LOCAL ADMINISTRATION	5

District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO, Municipal Corporation. Panchayati raj: Introduction, PRI: Zila Panchayat. Elected officials and their roles, CEO Zila Panchayat: Position and role. Block level: Organizational Hierarchy (Different departments), Village level: Role of Elected and Appointed officials, Importance of grass root democracy.

UNIT – VI	ELECTION COMMISSION	5

Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners – Institute and Bodies for the welfare of SC/ST/OBC and women.

Total Periods:	**30**

Reference Books:

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar 'Framing of Indian Constitution', 1st Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edition, Lexis Nexis, 2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015

Course Outcomes (CO)

CO1	Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics
CO2	Address the growth of Indian opinion regarding modern Indian intellectuals' constitutional
CO3	Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India
CO4	The eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
CO5	Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru.
CO6	Discuss the passage of the Hindu Code Bill of 1956.

Course Outcomes	**Program Outcomes**												**PSO**			
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**	**1**	**2**	**3**	**4**	**5**
CO1	1	1	1	1	1	1	1	1	3	2	1	1	1	1	1	1	1
CO2	1	1	1	1	1	1	1	1	3	2	1	1	1	1	1	1	1
CO3	1	1	1	1	1	1	1	1	3	2	1	1	1	1	1	1	1
CO4	1	1	1	1	1	1	1	1	3	2	1	1	1	1	1	1	1
CO5	1	1	1	1	1	1	1	1	3	2	1	1	1	1	1	1	1
C06	1	1	1	1	1	1	1	1	3	2	1	1	1	1	1	1	1

AX1006	PEDAGOGY STUDIES	L	T	P	C
		2	0	0	0

Objectives

- Review existing evidence on their view topic to inform programme design and policy
- Making under taken by the DFID, other agencies and researchers.
- Identify critical evidence gaps to guide the development

UNIT – I	INTRODUCTION AND METHODOLOGY	6

Aims and rationale, Policy background, Conceptual framework and terminology – Theories of learning, Curriculum, Teacher education – Conceptual framework, Research questions – Overview of methodology and Searching.

UNIT – II	THEMATIC OVERVIEW	6

Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries – Curriculum, Teacher education.

UNIT – III	EVIDENCE ON THE EFFECTIVENESS OF PEDAGOGICAL PRACTICES	6

Methodology for the in–depth stage: quality assessment of included studies – How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? – Theory of change – Strength and nature of the body of evidence for effective pedagogical practices – Pedagogic theory and pedagogical approaches – Teachers' attitudes and beliefs and Pedagogic strategies.

UNIT – IV	PROFESSIONAL DEVELOPMENT	6

Professional development: alignment with classroom practices and follow up support – Peer support – Support from the head teacher and the community – Curriculum and assessment – Barriers to learning: limited resources and large class sizes.

UNIT – V	RESEARCH GAPS AND FUTURE DIRECTIONS	6

Research design – Contexts – Pedagogy – Teacher education – Curriculum and assessment – Dissemination and research impact.

Total Periods: 30

Reference Books:

1. J. Ackers, F. Hardman, 'Classroom interaction in Kenyan primary schools', Compare, Vol. 31, No. 2, Page: 245–261, 2001.
2. M. Agrawal, 'Curricular reform in schools: The importance of evaluation', Journal of Curriculum Studies, Vol. 36, No. 3, Page: 361–379, 2004.
3. K. Akyeampong, 'Teacher training in Ghana–does it count? Multi–site teacher education research project' (MUSTER) Country report 1, London, 2003.
4. K. Akyeampong, K. Lussier, J. Pryor and J. Westbrook, 'Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count?' International Journal Educational Development, Vol. 33, No. 3, Page: 272–282, 2013.
5. R. J. Alexander 'Culture and pedagogy: International comparisons in primary education', Oxford and Boston: Blackwell, 2001.
6. M. Chavan, 'Read India: Amass scale, rapid, 'learning to read' campaign', 2003.
7. www.pratham.org/images/resource%20working%20paper%202.pdf.

Course Outcomes (CO)

CO1	Students will be able to understand what pedagogical practices are being used by teacher's formal classrooms in developing countries.
CO2	Students will be able to understand what pedagogical practices are being used by teacher's informal classrooms in developing countries.
CO3	Students will be able to understand the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners.
CO4	Students will be able to understand how a teacher can teach the education (curriculum and practicum).
CO5	The school curriculum and guidance materials best support effective pedagogy is prepared by a teacher.

Course Outcomes	Program Outcomes												PSO				
	a	b	c	d	e	f	g	h	i	j	k	l	1	2	3	4	5
CO1	1	1	1	1	1	1	1	1	2	2	1	2	1	1	1	1	1
CO2	1	1	1	1	1	1	1	1	2	2	1	2	1	1	1	1	1
CO3	1	1	1	1	1	1	1	1	2	2	1	2	1	1	1	1	1
CO4	1	1	1	1	1	1	1	1	2	2	1	2	1	1	1	1	1
CO5	1	1	1	1	1	1	1	1	2	2	1	2	1	1	1	1	1

AX1007	STRESS MANAGEMENT BY YOGA	L	T	P	C
		2	0	0	0

Objectives

- To achieve overall health of body and mind
- To overcome stress

UNIT – I	10

Definitions of Eight parts of yoga. (Ashtanga)

UNIT – II	10

Yam and Niyam – Do`s and Don't's in life – i) Ahinsa, satya, astheya, bramhacharya and aparigraha, ii) Ahinsa, satya, astheya, bramhacharya and aparigraha.

UNIT – III	10

Asan and Pranayam – Various yoga poses and their benefits for mind & body – Regularization of breathing techniques and its effects – Types of pranayam

Total Periods:	30

Reference Books:

1. 'Yogic Asanas for Group Tarining–Part–I', Janardan Swami Yoga bhyasi Mandal, Nagpur.
2. 'Rajayoga or conquering the Internal Nature, by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata.

Course Outcomes (CO)

CO1	Students will be able to develop healthy mind in a healthy body.
CO2	Improve efficiency
CO3	Healthy mind students helps in improving social health also.

Course Outcomes	Program Outcomes												PSO				
	a	b	c	d	e	f	g	h	i	j	k	l	1	2	3	4	5
CO1	1	1	1	1	1	1	1	1	1	1	1	3	1	1	1	1	1
CO2	1	1	1	1	1	1	1	1	1	1	1	3	1	1	1	1	1
CO3	1	1	1	1	1	1	1	1	1	1	1	3	1	1	1	1	1

AX1008	**PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS**	**L**	**T**	**P**	**C**
		2	**0**	**0**	**0**

Objectives

- To learn to achieve the highest goal happily
- To become a person with stable mind, pleasing personality and determination
- To awaken wisdom in students

UNIT – I	**10**

Neetisatakam – holistic development of personality – Verses–19,20,21,22 (wisdom) – Verses–29,31,32 (pride & heroism) – Verses–26,28,63,65 (virtue) – Verses–52,53,59 (dont's) – Verses–71,73,75,78 (do's)

UNIT – II	**10**

Approach to day–to–day work and duties – Shrimad Bhagwad Geeta: Chapter 2 – Verses 41, 47,48 – Chapter 3 – Verses 13, 21, 27, 35 Chapter 6–Verses 5,13,1

UNIT – III	**10**

Statements of basic knowledge – Shrimad Bhagwad Geeta: Chapter2 – Verses 56, 62, 68 Chapter 12 – Verses 13, 14, 15, 16,17, 18 – Personality of role model – Shrimad Bhagwad Geeta – Chapter2 – Verses 17, Chapter 3 – Verses 36,37,42 – Chapter 4 – Verses 18, 38,39 Chapter18 – Verses 37,38,63

Total Periods:	**30**

Reference Books:

1. Gopinath, P. Rashtriya Sanskrit Sansthanam, 'Bhartrihari's Three Satakam', Niti–sringar–vairagya, New Delhi, 2010.
2. Swami Swarupananda, 'Srimad Bhagavad Gita', Advaita Ashram, Publication Department, Kolkata, 2016.

Course Outcomes (CO)

CO1	Students will be able to study the Shrimad–Bhagwad–Geeta that will help the student in developing his personality and achieve the highest goal in life
CO2	The person who has studied Geeta will lead the nation and mankind to peace and prosperity
CO3	Study of Neet is hatakam will help in developing versatile personality of students.

Course Outcomes	Program Outcomes												PSO				
	a	b	c	d	e	f	g	h	i	j	k	l	1	2	3	4	5
CO1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1
CO2	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1
CO3	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1