Scheme of Instruction and Syllabi

Master of Engineering

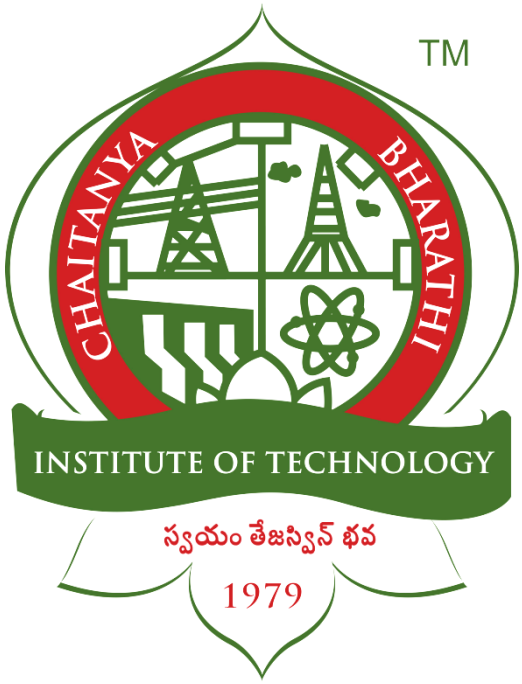
A TWO YEAR (I – IV Semesters) PG Program

in

POWER SYSTEMS AND POWER ELECTRONICS

(AICTE Model Curriculum with effect from AY 2023-24)

(R–23 Regulation)



CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY

(Autonomous Institution under UGC, Affiliated to Osmania University)

Department of Electrical and Electronics Engineering

Accredited by NBA and NAAC-UGC

Chaitanya Bharathi (Post), Gandipet, Hyderabad–500075

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY (A)

OUR MOTTO: SWAYAM TEJASWIN BHAVA

VISION and MISSION of the INSTITUTE

Vision

To be a centre of excellence in technical education and research.

Mission

To address the emerging needs through quality technical education and advanced research.

VISION and MISSION of the DEPT. of EEE

Vision

To achieve Academic and Professional Excellence in Teaching and Research in the frontier areas of Electrical and Electronics Engineering **Vis-a -Vis** serve as a Valuable Resource for Industry and Society.

Mission

Empowering the Faculty and Student Rendezvous to Nurture Interest for Conceptual Keystone, Applied Multidisciplinary Research, Inspiring Leadership and Efficacious Entrepreneurship culture, Impeccable Innovation in frontier areas to be synergetic with Environmental, Societal and Technological Developments of the National and International community for Universal Intimacy.

M1: Emphasis on providing Strong Theoretical Foundation & Engineering Leadership Eminence, infusion of Creativity and Management skill while maintaining Ethics and Moral for Sustainable Development. (Individual development)

M2: Enable the Faculty and Student Interactions to trigger interest for Applied Multidisciplinary Research and Entrepreneurship Culture resulting in Significant Advancement of the field of Specialization with Involvement of Industries and Collaborative Educational Networks. (Sense of Ownership, Networking and Eco system Development).

M3: Extend the Conducive Neighborhoods for Innovation in frontier areas to keep pace with Environmental, Societal and Technological Developments of the National and International Community to Serve Humanity. (Service to Society, Atmanirbhar Bharat)

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

Program Educational Objectives of M.E (Power Systems & Power Electronics) Program

PEO1: Will excel in Power System and Power Electronics area.

PEO2: Will become successful in executing software related applications.

PEO3: Will carry out research in new technologies relevant to PS & PE.

PEO4: Will develop with professional ethics, effective communication skills and knowledge of societal impacts of computing technologies.

Program Outcomes of M.E (Power Systems & Power Electronics) Program

PO1: An ability to independently carry out research/investigation and development work to solve practical problems.

PO2: Ability to write and present a substantial technical report/document.

PO3: Students should be able to demonstrate a degree of mastery in the area of PS & PE.

PO4: Ability to discriminate the capability and knowledge in order to refine the problem formulation and methods of solution which will result into an acceptable outcome.

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY

In line with AICTE Model Curriculum with effect from AY 2023-24

M.E (Power Systems and Power Electronics)

SEMESTER – I

S.no	Course Code	Title of the Course	Scheme of Instruction			Scheme of Examination			Credits
			Hours Per Week			Duration of SEE in Hours	Maximum Marks		
			L	T	P/D		CIE	SEE	
THEORY									
1	23EEC101	Real-Time Control of Power Systems	3	-	-	3	40	60	3
2	23EEC102	Analysis of Power Converters	3	-	-	3	40	60	3
3	23EEE1XX	Program Elective-I	3	-	-	3	40	60	3
4	23EEE1XX	Program Elective-II	3	-	-	3	40	60	3
5	23MEM103	Research Methodology and IPR	2	-	-	3	40	60	2
6	AC-I	Audit Course-I	2	-	-	2		50	NC
PRACTICALS									
7	23EEC103	Advanced Power System Lab	-	-	3	-	50	--	1.5
8	23EEC104	Advanced Power Electronic Circuits and Drives Lab	-	-	3	-	50	--	1.5
Total			**16**	**-**	**6**	**17**	**300**	**350**	**17**
Clock Hours Per Week: 22									

L: Lecture D: Drawing **CIE: Continuous Internal Evaluation**

T: Tutorial P: Practical/Project Seminar/Dissertation SEE: Semester End Examination

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY

In line with AICTE Model Curriculum with effect from AY 2023-24

M.E (Power Systems and Power Electronics)

SEMESTER – II

S.no	Course Code	Title of the Course	Scheme of Instruction			Scheme of Examination			Credits
			Hours Per Week			Duration of SEE in Hours	Maximum Marks		
			L	T	P/D		CIE	SEE	
THEORY									
1	23EEC105	Advanced Computational Methods in Power Systems	3	-	-	3	40	60	3
2	23EEC106	Power Converters and Control Techniques for Microgrids	3	-	-	3	40	60	3
3	23EEC107	Data Science Applications in Power Engineering	3	-	-	3	40	60	3
4	23EEE1XX	Program Elective-III	3	-	-	3	40	60	3
5	23EEE1XX	Program Elective-IV	3	-	-	3	40	60	3
PRACTICALS									
6	23EEC108	Power Systems Computational Lab	-	-	3	-	50	-	1.5
7	23EEC109	Data Science Applications Lab	-	-	3	-	50	-	1.5
8	23EEC110	Mini Project	-	-	2	-	50	-	1
Total			**15**	**-**	**8**	**15**	**350**	**300**	**19**
Clock Hours Per Week: 23									

L: Lecture D: Drawing **CIE: Continuous Internal Evaluation**

T: Tutorial P: Practical/Project Seminar/Dissertation SEE: Semester End Examination

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY

In line with AICTE Model Curriculum with effect from AY 2023-24

M.E (Power Systems and Power Electronics)

SEMESTER – III

S.no	Course Code	Title of the Course	Scheme of Instruction			Scheme of Examination			Credits
			Hours Per Week			Duration of SEE in Hours	Maximum Marks		
			L	T	P/D		CIE	SEE	
THEORY									
1	23EEE1XX	Program Elective-V	3	-	-	3	40	60	3
2	OE	Open Elective	3	-	-	3	40	60	3
3	AC-II	Audit Course-II	2	-	-	2	-	50	NC
4	23EEC111	Industrial Project /Dissertation Phase I	-	-	20	-	100	-	10
Total			**8**	**-**	**20**	**8**	**180**	**170**	**16**
Clock Hours Per Week: 28									

L: Lecture D: Drawing **CIE: Continuous Internal Evaluation**

T: Tutorial P: Practical/Project Seminar/Dissertation **SEE: Semester End Examination**

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY

In line with AICTE Model Curriculum with effect from AY 2023-24

M.E (Power Systems and Power Electronics)

SEMESTER – IV

S.no	Course Code	Title of the Course	Scheme of Instruction			Scheme of Examination			Credits
			Hours Per Week			Duration of SEE in Hours	Maximum Marks		
			L	T	P/D		CIE	SEE	
THEORY									
1	23EEC112	Industrial Project /Dissertation Phase II	-	-	32	Viva - Voce	100	100	16
Total			**-**	**-**	**32**	**-**	**100**	**100**	**16**
Clock Hours Per Week: 32									

L: Lecture D: Drawing **CIE: Continuous Internal Evaluation**

T: Tutorial P: Practical/Project Seminar/Dissertation **SEE: Semester End Examination**

Note: Students undergoing internships during the semester, applied through the training and placement office are permitted to take up equivalent courses through MOOCs /SWAYAM to earn required credits. However, such students should seek prior permission from the Chairman, BoS.

List of Program Elective/Open Elective s/Audit Courses

Elective-I	
23EEE101	Restructured Power systems
23EEE102	Design of Power Electronic Converters
23EEE103	Signal Processing Techniques
23EEE104	Digital Control Systems
23EEE105	Smart Appliances and Internet of Things
Elective-II	
23EEE106	Smart Electrical Distribution System
23EEE107	Modeling and Analysis of Renewable Energy Sources
23EEE108	Advanced Electric Drives
23EEE109	Distribution System Planning and Automation
23EEE110	Machine Learning and Application
Elective-III	
23EEE111	Power Quality Improvement Techniques
23EEE112	High Power Inverters
23EEE113	Industrial and Strategic Applications of Superconductivity
23EEE114	Modern Control Theory
23EEE115	Smart Grid Technologies
Elective-IV	
23EEE116	Power System Dynamics
23EEE117	Power Electronics for Power systems
23EEE118	Control and Integration of Renewable Energy Sources
23EEE119	Microgrid Dynamics and Control
23EEE120	Evolutionary Algorithms Applications in Power Engineering
Elective-V	
23EEE121	Digital Protection of Power Systems
23EEE122	Advanced Control Techniques for Power Converters
23EEE123	Electric and Hybrid Vehicles
23EEE124	Wide Area Monitoring and Control
23EEE125	Energy Auditing and Management
Open Electives	
23CSO101	Business Analytics
23MEO101	Industrial Safety
23MEO102	Introduction to optimization Techniques
23MEO103	Composite Materials
23CEO101	Cost Management of Engineering Projects
Audit Courses	
23EGA101	English for Research Paper Writing
23EGA102	Indian Constitution and Fundamental Rights
23EGA103	Stress Management by Yoga
23EGA104	Personality Development through Life Enlightenment Skills
23ECA101	Value Education
23CEA101	Disaster Mitigation and Management
23IT A101	Pedagogy Studies
23EEA101	Sanskrit for Technical Knowledge

With effect from AY 2023-24

23EEC101

REAL TIME CONTROL OF POWER SYSTEMS

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge on power system operation, control and analysis

Course Objectives:

This course aims to:

1. Understand the importance of state estimation in power systems.
2. Know the importance of security and contingency analysis.
3. Understand SCADA, its objectives, and its importance in power systems.

Course Outcomes:

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

1. Understand supervisory control and data acquisition.
2. Develop mathematical models for analysis of linear and nonlinear state estimation, Observability and Contingency analysis of any practical Power System
3. Prepare the practical input data required for linear and nonlinear state estimation methods and contingency analysis.
4. Analyze the power system security and challenges in secure operation of power systems.
5. Have a complete overview of Real Time operation of Power Systems (RTPS), communication and protocols employed in RTPS.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	3	2	2	2
CO 2	3	2	2	2
CO 3	2	2	3	1
CO 4	2	1	2	3
CO 5	2	3	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I

Computer Control of Power Systems: Need for real time and computer control of power systems, operating states of a power system, SCADA - Supervisory control and Data Acquisition systems implementation considerations, energy control centers, software requirements for implementing the above functions.

UNIT - II

State Estimation: Different types of State Estimations, Theory of WLS state estimation, sequential and non-sequential methods process measurements, Bad data Observability, Bad data detection, identification and elimination.

UNIT - III

Security Analysis of Power Systems: Concept of security – Security analysis and monitoring – factors affecting Power System Security – Contingency Analysis for Generator and Line Outages by Fast Decoupled Inverse Lemma–based approach – Network Sensitivity factors. Contingency selection

UNIT - IV

Synchrophasor Measurement Units: Introduction, Phasor representation of sinusoids, a generic PMU, GPS, Phasor measurement systems, Communication options for PMUs, Functional requirements of PMUs and PDCs, Phasors for nominal frequency signals, types of frequency excursions in power systems, DFT estimation at off nominal frequency with a nominal frequency clock.

UNIT - V

State Load Dispatch Center (SLDC): Inter Connectivity of Sub-LDCs & SLDCs, Hierarchy of Data Transfer, Functions & Responsibilities of SLDC, Real Time Operation carried at SLDC.

Text Books:

1. John J.Grainger and William D.Stevenson, Jr., "Power System Analysis", International Edition, McGraw-Hill, 1994.
2. Allen J.Wood and Bruce F.Wollenberg, "Power Generation operation and control", John Wiley & Sons, 1984.

Suggested Reading:

1. A.G.Phadka and J.S. Thorp, "Synchronized Phasor Measurements and Their Applications", Springer, 2008
2. IEEE Proc, "Special Issue on Computer Control of Power Systems", July 1974.
3. L.P.Singh, "Advanced Power System Analysis and Dynamics", Wiley Eastern Ltd., 1986.

With effect from AY 2023-24

23EEC102

ANALYSIS OF POWER CONVERTERS

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge of Power Electronics

Course Objectives:
This course aims to:
1. Understand the switching characteristics of Power Electronic Devices.
2. Understand the operation of advanced power electronic circuit topologies.
3. Understand the design aspects of magnetic components that are used for power converters.

Course Outcomes:
Upon completion of this course, students will be able to:
1. Select appropriate switching devices for power converters.
2. Design switch mode converters like buck, boost, buck-boost and Cuk converters.
3. Analyze the Switching DC Power Supplies.
4. Analyze and design load and switch resonant converters.
5. Synthesize and design magnetic components for power converter.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	2	1	3	2
CO 2	3	2	3	3
CO 3	2	-	3	-
CO 4	2	1	3	2
CO 5	2	1	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I
Overview of Switching Power Devices: Static and dynamic characteristics of switching devices: BJT, MOSFET, IGBT, GTO, Wide band gap devices (GaN, SiC) - Design of driver and snubber circuit.

UNIT - II
DC-DC Switch-Mode Converters: Control of dc-dc Converters, Buck, Boost, Buck-Boost, Cuk converters.

UNIT - III
Switching DC Power Supplies: Linear Power Supplies, Overview of Switching Power Supplies dc-dc Converters with Electrical Isolation, Classification- Fly-back converters forward converters, Push pull converters, Full bridge converters,

UNIT - IV
Resonant Converters: Introduction, Basic resonant circuit concepts, Classification - Load resonant converters, Resonant switch converters, zero voltage switching clamped voltage converters, Resonant DC link inverters, High frequency link integral half cycle converters,

UNIT - V

Design of Power Converters Components: Design of magnetic components - design of transformer, design of inductor and current transformer - Selection of filter capacitors, Selection of ratings for devices, input filter design, Thermal design

Text Books:

1. Ned Mohan, Tore M. Undeland, William P. Robbins, “Power Electronics- Converters, Applications”, 3rd Edition J.Wiley & Sons, 2003.
2. M.H. Rashid “Power Electronics- Circuits, Devices, and Applications”, 4th Edition Pearson, 2013.
3. BIN Wu, 'High Power Converters and AC Drives', IEEE press Wiley Inderscience, a John wiley & sons Inc. publication 2006

Suggested Reading:

1. Abraham I. Pressman, Keith Billings & Taylor Morey, “Switching Power Supply Design”, 3rd Edition, McGraw Hill International, 2009.
2. R.W.Erickson and Dragan Maksimonic, “Fundamentals of Power Electronics", 2nd Edition, Springer, 2001.
3. L.Umanand, “Power Electronics Essentials & Applications”,1st Edition, Wiley publishing Company, 2014.
4. B. Jayant Balinga, “Advanced High Voltage Power Device Concepts”, Springer New York 2011. ISBN 978-1-4614-0268-8
5. Abraham I Pressman “Switching Power Supply Design” McGraw Hill Publishing Company., 2001.

NPTEL Courses:

S.No.	NPTEL Course Name	Instructor	Host Institute
1	Advance Power Electronics and Control	Prof. Avik Bhattacharya	IIT Roorkee
Other Online Resources:			
1	http://freevideolectures.com	-	-
2	http://engineeringvideolectures.com	-	-

With effect from AY 2023-24

23MEM103

RESEARCH METHODOLOGY AND IPR

Instruction	2 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	2

Prerequisite: None

Course Objectives:
This course aims to:

1. Motivate choose research as career.
2. Formulate the research problem, prepare the research design.
3. Identify various sources for literature review and data collection report writing.
4. Equip with good methods analyze the collected data.
5. Know about IPR copyrights.

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

1. Define research problems, review, and assess the quality of literature from various sources.
2. Improve the style and format of writing a report for technical paper/ Journal report, understand and develop various research designs.
3. Collect the data by various methods: observation, interview, questionnaires.
4. Analyze problems by statistical techniques: ANOVA, F-test, and Chi-square.
5. Understand apply for patent and copyrights.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	3	2	2	2
CO 2	3	3	1	1
CO 3	3	2	2	1
CO 4	3	1	2	2
CO 5	3	3	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT- I

Research Methodology: Objectives and Motivation of Research, Types of Research, research approaches, Significance of Research, Research Methods verses Methodology, Research Process, Criteria of Good Research, Problems Encountered by Researchers in India, Benefits the society in general. Defining the Research Problem: Selection of Research Problem, Necessity of Defining the Problem

UNIT- II

Literature Survey Report writing: Importance and purpose of Literature Survey, Sources of Information, Assessment of Quality of Journals and Articles, Information through Internet. Report writing: Meaning of interpretation, layout of research report, Types of reports, Mechanics of writing a report.

Research Proposal Preparation: Writing a Research Proposal and Research Report, Writing Research Grant Proposal

UNIT- III

Research Design: Meaning of Research Design, Need of Research Design, Feature of a Good Design, Important Concepts Related Research Design, Different Research Designs, Basic Principles of Experimental Design, Developing a Research Plan, Steps in sample design, types of sample designs.

UNIT- IV

Data Collection and Analysis: Data Collection: Methods of data collection, importance of Parametric, non-parametric test ,testing of variance of two normal populations, use of Chi-square, ANOVA, F test, z-test.

UNIT - V

Patents and Copy right: Patent: Macro economic impact of the patent system, Patent document, how protect your inventions. Granting of patent, Rights of a patent, how extensive is patent protection. Copyright: What is copyright. What is covered by copyright? How long does copyright last? Why protect copyright?

Related Rights: what are related rights? Enforcement of Intellectual Property Rights: Infringement of intellectual property rights, Case studies of patents and IP Protection

Text Books:

1. C.R Kothari, "Research Methodology, Methods & Technique"; New Age International Publishers, 2004
2. R. Ganesan, "Research Methodology for Engineers", MJP Publishers, 2011

Suggested Reading:

1. Ajit Parulekar and Sarita D' Souza, "Indian Patents Law – Legal & Business Implications"; Macmillan India ltd, 2006
2. B. L.Wadehra; "Law Relating Patents, Trademarks, Copyright, Designs & Geographical Indications"; Universal law Publishing Pvt. Ltd., India2000.
3. P. Narayanan; "Law of Copyright and Industrial Designs"; Eastern law House, Delhi 2010.

With effect from AY 2023-24

23EEC103

ADVANCED POWER SYSTEMS LAB

Instruction	3 P Hours per Week
Duration of SEE	-
SEE	-
CIE	50 Marks
Credits	1.5

Prerequisite: Students should have prior knowledge of power systems

Course Objectives:

This course aims to:

1. Understand the I–V and P- V characteristics of a PV module.
2. Measure the sequence reactance of synchronous machine and 3-phase transformer.
3. Estimate efficiency, regulation of a single-phase transmission line and to understand the characteristics of various relays.

Course Outcomes:

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

1. Find the sequence reactance of the synchronous machine and 3-phase transformer.
2. Plot the relay characteristics.
3. Calculate efficiency, regulation and ABCD constants of single-phase transmission line.
4. Learn about various types of faults.
5. Validate the I–V and P- V characteristics of a PV module.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	2	2	3	2
CO 2	2	2	3	2
CO 3	2	2	3	2
CO 4	2	2	3	2
CO 5	2	2	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

List of Experiments:

1. Determination of ABCD constants of a single- phase transmission line
2. Study of Inverse time characteristics of over current relay
3. Study of microprocessor based inverse current relay characteristics.
4. Study of over voltage and under voltage relays
5. Single PV module I- V and P- V characteristics with radiation and temperature changing effect.
6. I- V and P- V characteristics with series and parallel combination of modules.
7. Effect of shading and Effect of tilt angle on I- V and P- V characteristics of solar module.
8. Finding MPP by varying the resistive load by varying the duty cycle of DC-DC converter.
9. Mitigation of power quality parameters using series compensator
10. Mitigation of power quality parameters using Shunt compensator
11. Mitigation of power quality parameters using UPQC
12. Study & amp; Analysis of Voltage drop in Radial / Ring main distribution system.
13. Characteristics of Electromagnetic type Earth fault relay
14. Power Angle Characteristics of 3- Phase Synchronous Machine with infinite bus bars.
15. Harmonic analysis of non-liner loads using power analyzer

Note: TEN experiments be conducted to cover all five Course Outcomes.

With effect from AY 2023-24

23EEC104

ADVANCED POWER ELECTRONIC CIRCUITS AND DRIVES LAB

Instruction	3P Hours per Week
Duration of SEE	-
SEE	-
CIE	50 Marks
Credits	1.5

Prerequisite: Students should have prior knowledge of Power Electronics and Electrical Machines.

Course Objectives:
This course aims to:

1. Analyze AC-AC and DC-DC Converter topologies with different loads.
2. Analyze different inverter configurations with different switching techniques.
3. Simulate different open and closed loop DC and AC drives.

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

1. Understand the effect of source inductance on phase controllers.
2. Design inductors used in DC-DC Converter and also illustrate the converter performance with different types of loads.
3. Develop basic control schemes for different converters and implement it in MATLAB/SIMULINK platform.
4. Implement different control schemes for DC Drives and verify it experimentally and/or through simulation.
5. Implement different control schemes for AC Drives and verify it experimentally and/or through simulation.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	2	1	2	1
CO 2	3	1	3	3
CO 3	2	1	2	1
CO 4	3	1	3	2
CO 5	3	1	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

List of Experiments:

Part-A

1. Performance analysis of phase-controlled rectifiers with source inductance (single phase and three phase).
2. Analysis of three phase AC voltage controller with R & RL loads.
3. Analysis of DC-DC converters (a) Buck converter (b) Buck-Boost converter.
4. Closed loop control of Buck and Boost converter.
5. Analysis of ZVS buck converter.
6. Analysis of ZCS buck converter.
7. Analysis of single-phase and Three phase IGBT inverter.
8. Analysis of single-phase series-resonant inverter.
9. Quasi-square wave control of a Single-phase Full bridge VSI.

10. Voltage control of an inverter using unipolar & bipolar PWM techniques.
11. Design and development of inductors for dc-dc converter applications.

Part-B

1. Three -phase fully controlled converter fed dc drive.
2. Speed control of dc drive using dc chopper.
3. Simulation of chopper fed dc drive.
4. Closed-loop control of permanent magnet dc drive.
5. Experimental study of Static Kramer's drive.
6. Simulation of open loop based scalar controlled induction motor drive.
7. Simulation of closed loop scalar controlled induction motor drive.
8. Simulation of vector (Rotor field oriented) controlled induction motor drive.
9. Load Testing of BLDC Motor.
10. Speed Control of SRM.
11. Speed Control of PMSM.

Note:

1. From each section at least Five Experiments should be conducted.
2. A minimum of three hardware experiments be conducted from Part-A and two from Part-B.

With effect from AY 2023-24

23EEC105

ADVANCED COMPUTATIONAL METHODS IN POWER SYSTEMS

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge on power system analysis

Course Objectives:

This course aims to:

1. Understand the load flow analysis of power systems.
2. Analyze the load flows under renewable penetrated power systems.
3. Attain knowledge of power system components, its operation strategies, and stability analysis.

Course Outcomes:

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

1. Develop proper mathematical models for analysis of a selected problem like load flow study of Power System and Distribution Network or Fault analysis.
2. Determine Power flows with various load flow methods.
3. Obtain the power flows for distribution systems.
4. Develop power system software /implementation algorithm for fault analysis.
5. Find the fault currents by implementing algorithms for different faults.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	2	1	3	2
CO 2	2	2	2	1
CO 3	3	2	1	2
CO 4	2	2	1	3
CO 5	2	2	2	3

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I

Basic Power System Components and their Representation: Physical parameters – Significance of per UNIT - representation, Typical single line diagram of a power system. Concept of incidence matrix, formation of A and Â matrices, list of other types of incidence matrices and their limitations. Representation of Generator, Transmission lines and Transformers, Primitive and Network matrices, Ybus formation by Inspection method and its algorithm. Merits and Demerits of Y_{bus} and Z_{bus} matrices in Power System Analysis – Areas of application.

UNIT - II

Load Flow Analysis: Y_{bus} based Power System Static Load Flow Equations. Gauss-Seidel (GS) method, PV-bus treatment, Gauss-Seidel load flow algorithm. Need of Sparsity technique for 'well grown' power systems, Concept of Sparsity technique, Y_{bus} formation using Sparsity technique. GS with Sparsity technique. Merits and Demerits of GS method. Newton-Raphson (NR) load flow method and its algorithm. Merits and Demerits of NR method; Newton‟s Decoupled, Fast Decoupled equation, algorithm of Fast Decoupled (FDC) method. Merits and Demerits of FDC method; Areas of application of load flow study. AC/DC load flow solutions

UNIT - III

Distribution System Load Flow Methods: Load Flow Methods- Vector based load flow method, Backward-Forward Sweep method and Current injection method. Load flow studies with Renewable Energy Sources –Solar and Wind Energy Sources.

UNIT – IV

Short Circuit Studies: Need of short circuit studies – Assumptions in short circuit studies – Areas of application. Formation of Z_{bus} using step-by-step approach (Addition of a branch & Addition of a link). Modification of Z_{bus} elements for changes.

UNIT – V

Symmetrical Sequence Components: Significance of symmetrical components, approximations, formation of primitive Z_f^{abc}, V_f^{abc} ,Z_f^{012} and Y_f^{012} for various types of faults. formation of Z_{bus}^{012} by step-by-step algorithm. Derivation of relevant equations for $I_{p(f)}^{012}$, $E_{p(f)}^{012}$ and $E_{i(f)}^{012}$ for LLLG and LG faults.

Text Books:

1. Stagg and El – Abiad, “Computer Methods in Power System Analysis”, , McGraw Hill, ISE, 1986
2. M A Pai and Dr. Dheeman Chatterjee, “Computer techniques in Power System Analysis”, 3rd Edition, McGraw hill.

Suggested Reading:

1. Hadi Sadat, “Power System Analysis”, International Edition, McGraw Hill, 1999.
2. J.Arrilaga and NR Watson , “Computer Modeling of Electrical Power Systems”, , John Wiley and Sons.

With effect from AY 2023-24

23EEC106
POWER CONVERTERS AND CONTROL TECHNIQUES FOR MICROGRIDS

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge of Power Electronics and Control Systems.

Course Objectives:
This course aims to:
1. Introduce the fundamental concepts of microgrid and its components, types of microgrids, advantages of microgrid.
2. Describe general concepts and application, control strategies and principle of operation of DC microgrid.
3. Discuss the modeling of power converters used in microgrids.

Course Outcomes:
Upon completion of this course, students will be able to:
1. Understand the basic concepts and types of microgrid.
2. Analyze various control methods of microgrid.
3. Model different power converters required in microgrid.
4. Illustrate the control of AC microgrid.
5. Describe the need and control process of DC-DC converter control the DC microgrid.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	3	1	3	-
CO 2	3	1	3	-
CO 3	3	1	3	-
CO 4	3	1	3	-
CO 5	3	1	3	-

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I
Micro-Grid: Power system resilience, The concept of micro-grids, Types of micro-grids, Autonomous and non-autonomous grids, Sizing of micro-grids, Microgrid Modeling & Analysis, Micro-grids with multiple DGs. Standards and regulation issues associated with AC & DC microgrids, Comparison between AC and DC Microgrids.

UNIT - II
Microgrid Control: Centralized control, Hierarchical principle: Primary, secondary and tertiary control – Distributed control, Protection issues and Communication based techniques.

UNIT - III
Modeling of Power Electronic Converters in Microgrid application: Modeling of voltage source PWM rectifier, modeling of voltage source inverter in current controlled mode and voltage-controlled mode, modelling of boost DC-DC converter and its control, modeling of isolated bidirectional DC-DC converter and its control. Microgrid Dynamics: Modeling of AC & DC microgrid and its dynamic studies.

UNIT - IV

Control of grid connected inverter in AC Microgrid: Basics of Voltage-frequency control and P-Q control in AC microgrid, control of grid-forming inverter, control of grid-feeding inverter, control of grid-supporting power inverter, synchronization of inverters in ac microgrids.

UNIT - V

Control of DC-DC converter in DC Microgrid: Voltage control and power control in DC microgrid, control of parallel DC-DC converters in a DC microgrid, Advantages and Applications of DC microgrid.

Text Books:

1. Fusheng Li, Ruisheng Li, Fengquan Zhou, "Microgrid Technology and Engineering Application", Elsevier, 2015.
2. S. Chowdhury, P. Crossley, "Microgrids and Active Distribution Networks", Institution of Engineering and Technology, 2009.
3. Nikos Hatziargyriou, "Microgrids Architectures and Control", John Wiley Sons, 2014.
4. Hassan Bevrani, Bruno Francois, Toshifumi Ise, "Microgrid Dynamics and Control", John Wiley Sons, 2017

Suggested Reading:

1. Gevork B. Gharehpetian, S. Mohammad Mousavi Agah, Butterworth Heinemann, "Distributed Generation Systems: Design, Operation and Grid Integration", 2017.
2. Suleiman M. Sharkh, Mohammad A. Abusara , Georgios I. Orfanoudakis , Babar Hussain, "Power Electronic Converters for Microgrids", Wiley- IEEE Press, 2014.

NPTEL Courses:

S.No.	NPTEL Course Name	Instructor	Host Institute
1	DC Microgrid and Control System https://nptel.ac.in/courses/108107143	Prof. Avik Bhattacharya	IIT, Roorkee

With effect from AY 2023-24

23EEC107

DATA SCIENCE APPLICATIONS IN POWER ENGINEERING

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have knowledge of linear algebra, PDE, and Power Systems.

Course Objectives:

This course aims to:

1. Understand the data collection and data handling of real time power system problems.
2. Analyze the given data with various AI techniques.
3. Understand the role of data science in smart grid technologies.

Course Outcomes:

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

1. Distinguish between Algorithmic based methods and Knowledge based Methods.
2. Able to distinguish between Artificial Neural Networks and Fuzzy Logic.
3. Able to analyze the critical power system data with AI techniques.
4. Adopt Soft Computing techniques for solving Power Engineering Problems.
5. Apply appropriate AI framework for solving Power Engineering Problems.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	2	1	1	2
CO 2	1	2	1	2
CO 3	2	3	2	3
CO 4	3	1	2	3
CO 5	3	2	2	3

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I

Fuzzy Logic: Introduction – Classical and Fuzzy sets- Properties, Operations and relations-Fuzzy sets – Membership function -Basic Fuzzy set operations -Properties of Fuzzy sets – Fuzzy Cartesian Product - Operations on Fuzzy relations – Fuzzy logic – Fuzzy Cardinalities - Fuzzy Logic Controller (FLC): Fuzzy Logic System Components: Fuzzification - Inference Engine – Defuzzification methods

UNIT - II

Artificial Neural Networks (ANN): Introduction Artificial Neural Networks - Definition and Fundamental concepts -Biological Neural Network – modelling of a Neuron -Activation functions – initialization of weights - Typical architectures, Linear Separability – XOR Problem, Multi – layer perceptron using Back propagation Algorithm (BPA)

UNIT –III

Data Analytics for Power System: Introduction data availability in power systems, HD space, SVD, Application of

SVD in power system, analysis detections, application of learning in smart meter - Data visualization in elementary treatment - Dimensionality reduction - Principal Component Analysis (PCA) - PCA applications in power systems.

UNIT - IV

Deep Learning: Introduction deep learning, Bayesian learning, decision surface, linear classifier, linear machines with hinge loss, Deep Architectures – Convolutional Neural Networks – Convolutional Layer – Pooling Layer – Normalization Layer- Fully Connected Layer – Deep belief Networks, Applications – Room temperature control. .

UNIT - V

Applications of Data science in Power System: Load flow studies - Economic load dispatch - Load frequency control – Single area system and two area systems using Fuzzy, ANN, ANFIS, and Deep Learning.

Text Books:

1. S. Rajasekaran and G.A.V. Pai, "Neural Networks, Fuzzy Logic & Genetic Algorithms", PHI, New Delhi, 2008.
2. T.J. Ross, "Fuzzy Logic with Fuzzy applications", Mc Graw Hill Inc, 1997.

Suggested Reading:

1. Simon Haykin, "Neural Networks: A Comprehensive Foundations" Pearson Edition, 2003.
2. G.J.Klir and T.A.Folger, "Fuzzy sets, Uncertainty and Information", PHI, Pvt.Ltd,1994.

NPTEL Courses:

S.No.	NPTEL Course Name	Instructor	Host Institute
1	Introduction Machine learning	Dr. BalaramanRavindran	IITMadras
2	Neural Networks and Applications	Prof. Somnath Sengupta	IITKharagpur
3	Fuzzy Sets, Logic and Systems & Applications	Prof. Nishchal Kumar Verma	IIT Kanpur

With effect from AY 2023-24

23EEC108

POWER SYSTEM COMPUTATION LAB

Instruction	3 P Hours per Week
Duration of SEE	-
SEE	-
CIE	50 Marks
Credits	1.5

Prerequisite: Students should have prior knowledge of power systems

Course Objectives: This course aims to:

1. Simulate and study the various aspects of power system analysis.
2. Simulate and asses the stability and control of a power system.
3. Understand the application of soft computing techniques in power systems operation and control.

Course Outcomes:

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

1. Analyze the power system under various fault conditions.
2. Evaluate the economic dispatch in the power system operation.
3. Estimate the state and Asses the stability of a power system.
4. Analyze the security of power system during Line/Generator outages.
5. Analyze and select artificial intelligence techniques for the Power System operation and control.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	3	2	3	3
CO 2	3	2	3	3
CO 3	3	2	3	3
CO 4	3	2	3	3
CO 5	3	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

List of Experiments:

1. Formation of Z-Bus Matrix using Building Algorithm
2. Short Circuit Fault Analysis using Z-Bus
3. Load Flow Studies Using Gauss-Seidel and Newton-Raphson Method
4. Reactive Power Compensation in Transmission lines
5. Economic Load Dispatch in Power Systems
6. Single Area and Two Area Load Frequency Control
7. Transient Stability Studies
8. Solution of Swing Equation
9. State Estimation
10. Contingency Analysis
11. Load Flow Algorithm using ANN.
12. Single Area Load Frequency Control using Fuzzy Logic Toolbox.
13. Maximization of Sin(x) using Genetic Algorithm
14. Economic Load Dispatch using Genetic Algorithm
15. Economic Load Dispatch using Particle Swarm Optimization
16. State Estimation using PSO.

Note: At least **TEN** experiments should be conducted in the semester.

With effect from AY 2023-24

23EEC109

DATA SCIENCE APPLICATIONS LAB

Instruction	3 P Hours per Week
Duration of SEE	-
SEE	-
CIE	50 Marks
Credits	1.5

Prerequisite: Students should have prior knowledge of basic programming language, MATLAB, Power Systems and Power electronics.

Course Objectives:

This course aims to:

1. Provide knowledge of fuzzy logic and neural networks.
2. Provide knowledge on deep learning techniques.
3. Provide knowledge of various AI techniques.

Course Outcomes:

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

1. Analyze and choose suitable AI techniques for power system problems.
2. Design fuzzy logic rule-based system.
3. Understand and design neural networks for electrical engineering problems.
4. Understand basic concepts of deep learning algorithms.
5. Analysis of power electronics converters using AI Techniques.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	2	1	1	2
CO 2	1	2	1	2
CO 3	2	3	2	3
CO 4	3	1	2	3
CO 5	3	2	2	3

1 - Slightly; 2 - Moderately; 3 - Substantially

List of Experiments:

1. Identification of similarities in data attributes using Pearson coefficient method
2. Dimensionality reduction using principal component analysis (PCA)
3. Training ELD data set using K-nearest neighbors (KNN)
4. Training the LFC data set using Support vector machines (SVM)
5. Fuzzy based current control of Buck-Boost converter
6. Power measurement of RL circuit using Neural Network
7. ANN based AGC – Single area system.
8. Fuzzy Logic based AGC – Single area system.
9. ANFIS based AGC single area system.
10. Room temperature analysis using deep learning.
11. Load Flow analysis using Neural Network
12. Load forecasting using deep learning.
13. Power system Security using Neural Network
14. Classification of Fault using ANN

Note: At least **TEN** experiments should be conducted in the semester

With effect from AY 2023-24

23EEC110

MINI PROJECT

Instruction	2 P Hours per Week
Duration of SEE	-
SEE	-
CIE	50 Marks
Credits	1

Prerequisite: None

Course Objectives:
This course aims to:

1. Provide an opportunity for defining a problem statement through the practice of literature survey.
2. Motivate the students face the challenges in which demonstration of their competence in research techniques.
3. Provide an opportunity to contribute to the engineering arena in their own form.

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

1. Organize the literature review identify and formulate the engineering problem.
2. Provide engineering solutions for simple problems utilizing modern tools and methods.
3. Demonstrate a sound technical knowledge of their selected mini project topic.
4. Communicate with engineers and the community have consciousness of surroundings.
5. Adapt the skills and attitudes of a Professional Engineer.

General Instructions:

1. Mini Project is of 14-Week duration out of which one-Week prior reading, twelve Weeks of active research and final Week for presentation of their work for assessment.
2. Each student will be allotted a faculty supervisor for mentoring.

Methodology:

1. The student can select either mathematical modeling based / experimental investigations or numerical modeling.
2. All the investigations are clearly stated and documented with reasons / explanations.
3. The project should contain,
    i. A clear statement of research objectives
    ii. Background work
    iii. Literature review
    iv. Techniques used.
    v. Prospective deliverables
    vi. Benefit from this research
    vii. Detailed discussion on results
    viii. Conclusions and references

Assessment:

1. 50% of the marks for oral presentation which will take place at the end of the semester.
2. Evaluation will be done by a committee consisting of supervisor, one senior faculty and Head of the department or his nominee.
3. Evaluation will be carried out based on 'RUBRIC' (which will be supplied by the dept.)
4. 50% of the marks for scientific report on the project.
5. Report should be written as per standard journal format. The repertoire of the report content can be taken from the department.

With effect from AY 2024-25

23EEC111

INDUSTRIAL PROJECT/DISSERTATION PHASE-1

Instruction	20 P Hours per Week
Duration of SEE	-
SEE	-
CIE	100 Marks
Credits	10

Prerequisite: Students should have prior Domain-specific knowledge, Research Methodology

Course Objectives:

This course aims to:

1. Provide students with hands-on experience in working with industrial equipment and tools used in the power systems and power electronics industry.
2. Help students develop a thorough understanding of the practical applications of power electronics and power systems in real-world scenarios.
3. Develop students' ability to analyze and design power systems and power electronics circuits using appropriate software tools.

Course Outcomes:

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

1. Apply theoretical knowledge practical problems related to power systems and power electronics.
2. Analyze and design the power systems and power electronics circuits using appropriate software tools.
3. Understand the significance of industrial equipment and tools used in the power systems and power electronics industry.
4. Explore the latest trends and technologies in the field of power systems and power electronics and get familiar with Industry standards, ethics, safety and environmental issues.
5. Develop solutions to real-world problems and also Professionalism in attitude, behavior, and work ethics.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	3	3	2	2
CO 2	3	3	2	2
CO 3	3	3	3	3
CO 4	3	3	3	2
CO 5	3	3	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Guidelines:

PART-A: The student should

1. Be punctual and regular in attending all project-related activities, including classes, laboratory sessions, and field visits.
2. Be open to learning new skills and techniques used in the Power Systems and Power Electronics Industry.
3. Take initiative and be proactive in seeking guidance and support from their project guide or mentor.
4. Maintain a detailed record of project work, including laboratory notes, project reports, and presentations.
5. Conduct himself/herself in a professional manner, including adhering to ethical standards, respecting diversity and differences, and maintaining a positive attitude towards their work.

PART-B: The student should

1. Know that Continuous Internal Evaluation (CIE) by the supervisor and Departmental committee is based on the following table.
2. Present the work carried by him/her with the Departmental committee which Consists of Head, Chairperson-BoS, Supervisor and Project Coordinator followed by External Examiner [depending upon the case]

Guidelines for the award of marks: Max.Marks:100		
Evaluation by	**Max. Marks**	**Evaluation Criteria / Parameter**
Supervisor	30	Project Status / Review
	20	Report
Departmental Committee	10	Relevance of the Topic & Literature survey
	10	PPT Preparation
	10	Presentation
	10	Response Queries
	10	Report Submission

With effect from AY 2024-25

23EEC112

INDUSTRIAL PROJECT/DISSERTATION PHASE-2

Instruction	32 P Hours per Week
Duration of SEE	-
SEE	100 Marks
CIE	100 Marks
Credits	16

Prerequisite: Students should have successfully completed the Phase-1 and also acquired the skillset related Literature Review, Technical Writing and Project Management

Course Objectives:

This course aims to:

1. Provide students with advanced technical knowledge and skills in power systems and power electronics to undertake complex industrial projects.
2. Help students develop a deep understanding of industrial project management, including project planning, execution, and evaluation.
3. Develop students' research methodology skills and the ability to conduct independent research related to power systems and power electronics.

Course Outcomes:

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

1. Explore all the possible solutions to practical problems related to power systems and power electronics.
2. Design a given power system and power electronics circuits using appropriate software tools.
3. Identify right the industrial equipment and tools required for a given problem in the power systems and power electronics industry.
4. Familiar with the latest trends and technologies in the field of power systems and power electronics and with Industry standards, ethics, safety, and environmental issues
5. Develop Professionalism in Research report writing, attitude, behavior, and leadership,

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	3	3	2	2
CO 2	3	3	2	2
CO 3	3	3	3	3
CO 4	3	3	3	2
CO 5	3	3	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Guidelines:

PART-A: The student should

1. Be punctual and regular in attending all project-related activities, including classes, laboratory sessions, and field visits. in the power systems and power electronics industry
2. Take initiative and be proactive in seeking guidance and support from their project guide /supervisor or mentor.

3. Develop good communication skills, including the ability express ideas clearly and concisely, and listen actively to feedback and suggestions.
4. Maintain a detailed record of project work, including laboratory notes, project reports, and presentations.
5. Conduct himself/herself in a professional manner, including adhering to ethical standards, respecting diversity and differences, and maintaining a positive attitude towards your work.

PART-B: The student should

1. Know that Continuous Internal Evaluation (CIE) by the supervisor and Departmental committee is based on the following table.
2. Present the work carried by him/her with the Departmental committee which Consists of Head, Chairperson-BoS, Supervisor and Project Coordinator followed by External Examiner [depending upon the case]

Evaluation by	Max. Marks	Evaluation Criteria/Parameter
Department Review Committee	05	Review1
	10	Review2
	10	Submission
	15	Final presentation with the draft copy of report in standard format
	10	Submission of report in standard format
Supervisor	10	Regularity and Punctuality
	10	Work Progress
	10	Quality of the work which may lead publications
	10	Report Preparation
	10	Analytical / Programming/ Experimental Skills

Evaluation by	Max. Marks	Evaluation Criteria / Parameter
External and Internal Examiners together	20	Power Point Presentation
	30	Quality of Thesis Evaluation
	10	Publication/ Patent/Prototype/product
	20	Quality of the project ● Innovations ● Applications ● Live Research Projects ● Scope for future study ● Application society
	20	Viva- Voce

With effect from AY 2023-24

23EEE101

RESTRUCTURED POWER SYSTEMS

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
Semester End Examination	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge on power systems

Course Objectives:

This course aims to:

1. Understand open access and operation of power systems in deregulated and competitive environment.
2. Understand the role of ISO in pool markets, Bilateral markets and transmission pricing issues.
3. Understand different aspects of managing ancillary services and open access same time information system.

Course Outcomes:

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

1. Analyze the operation of power system in de-regulated and competitive environment.
2. Understand operation and planning policies in deregulated environment.
3. Explore various transmission pricing methodologies.
4. Distinguish different ancillary services provided by the ISO.
5. Understand open access same-time information system.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	2	3	3	3
CO 2	2	3	3	2
CO 3	3	3	3	3
CO 4	3	2	3	3
CO 5	3	2	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I

Introduction Power System Deregulation: Operation of vertically integrated power systems, Fundamental of Restructured systems, Benefits of deregulation, Power pools, Energy Brokerage system, Electricity market models, Market models based on contractual arrangements, Market architecture, Spot market, Day-ahead market and retail market, Models for trading arrangements. Congestion management.

UNIT - II

Power System Operation in Competitive Environment: Operational planning activities of ISO, ISO in pool markets, ISO in bilateral markets, Operational planning activities of a GENCO, UNIT -commitment in deregulated environment, Competitive bidding. Risk assessment.

UNIT - III

Transmission Pricing Issues: Power wheeling, transmission open access, cost components in transmission, pricing of power transactions, Transmission cost allocation methods, Postage stamp method, Contract path method, MW-

Mile method, MVA-Mile method, Unused transmission capacity method, Comparison of cost allocation methods.

UNIT - IV

Ancillary Services Management: Types of ancillary services, classification of ancillary services, load generation balancing related services, frequency regulation, load following, voltage control and reactive power support service, black start capability service, Synchronous generators as ancillary service providers. Standard market design.

UNIT - V

Open Access Same-time Information System: Structure of oasis, posting of information, Transfer capability on oasis, Definitions- ATC, TTC, TRM, CBM, Methodologies calculate ATC. Developments in India, IT applications in Restructured markets.

Text Books:

1. Lai, L.L. (Editor.), 'Power System Restructuring and Deregulation', John Wiley and Sons Ltd., 2001.
2. Bhattacharya, K., Bollen, M.H.J., and Daalder, J.E., 'Operation of Restructured Power Systems', Kluwer Academic Publishers. 2001

Suggested Reading:

1. LorrinPhilipson, H. Lee Willis, "Understanding electric utilities and de- regulation", Marcel Dekker Pub.,1998.
2. Steven Stoft, "Power system economics: designing markets for electricity", John Wileyand Sons, 2002.
3. M.Ilic, F.Galiana and L.Fink, 'Power System Restructuring Engineering and Economics', Kluwer Academic Publishers 1998.
4. Md Shahidephpour& M. Alomoush, 'Restructured Electrical Power Systems', Marcel Dekker Inc, 2001.

With effect from AY 2023-24

23EEE102

DESIGN OF POWER ELECTRONIC CONVERTERS

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have an introductory course on power electronics.

Course Objectives:
This course aims to:
1. Introduce the switching behavior of power semiconducting devices.
2. Impart the knowledge of design of driver and protection circuits for power semiconducting switches.
3. Know the sources, effects & control techniques of EMI.

Course Outcomes:
Upon completion of this course, students will be able to:
1. Understand the switching behavior of various static switches.
2. Design proper drive circuits and thermal design for power semiconducting switches
3. Design inductors and transformers for high frequency applications.
4. Model snubbers for the electronic switches.
5. Recognize what EMI is, sources & effects of Electromagnetic Interferences in power electronic systems and various methods control EMI.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	3	1	2	1
CO 2	3	1	2	1
CO 3	3	1	2	1
CO 4	3	1	2	1
CO 5	3	1	2	1

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I
Overview of Power Semiconductor Devices: Switching behavior of diode, MOSFET and IGBT, Bipolar Power Transistors, SCRs, TRIACs, Ultra-Fast Recovery Diodes, Schottky Diodes

UNIT - II
Gate Drivers and Thermal Design: Gate driver circuits for fully controlled switches, optocouplers Pulse transformer-based gate drivers, Power loss, Heat transfer – conduction, convection and radiation; Cooling – liquid cooling, vapour – phase cooling; Guidance for hear sink selection – Thermal resistance and impedance -Electrical analogy of thermal components, heat sink types and design – Mounting types choosing of heat sinks.

UNIT - III
Inductors Design: Behavior of inductors and capacitors in high frequency switching applications, Magnetic losses,

conducting losses, magnetic materials, magnetic core, Design of inductor and design of transformer.

UNIT - IV

Design of Snubbers: RC snubber circuit, under damped, over damped and critically damped cases. Design of RC snubber, RCD snubbers, Selection of power converter capacitor, PCB ground and design of PCB

UNIT - V

EMI in Power Electronics: Introduction of EMI, EMI measurements, EMI in power electronics. Common mode noise and differential mode noise, design solution of EMI, EMI filter enclose design. Proper PC layout, shielded cables, twisting of wire design of EMI filter.

Text Books:

1. Ned Mohan, Tore M. Undeland, William P. Robbins, "Power Electronics: Converters, Applications, and Design",3rd Edition Wiley, 2007.
2. Muhammad H. Rashid, "Power Electronics: Circuits, Devices and Applications", 4th Edition, Pearson Education, 2017.
3. Mark I. Montrose, "EMC and the Printed Circuit Board: Design, Theory, and Layout Made Simple", Wiley- IEEE Press, 1998.

Suggested Reading:

1. S. P. Seth, "Elements of Electromagnetic Fields", Danpat Rai & Co, 2011.
2. François Costa, Eric Laboure, Bertrand Revol, "Electromagnetic Compatibility in Power Electronics", Wiley, 2014.
3. Ashutosh Pramanik, "Electromagnetism Theory and Applications", 3rd Edition, PHI Pvt. Ltd., 2015.

NPTEL Courses:

S.No.	NPTEL Course Name	Instructor	Host Institute
1	Design f Power Electronic Converters https://archive.nptel.ac.in/courses/117/103/117103148/	Prof. Shabari Nath	IIT, Guwahati

With effect from AY 2023-24

23EEE103

SIGNAL PROCESSING TECHNIQUES

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Basic knowledge on the courses signals & systems and digital signal processing

Course Objectives:
This course aims to:
1. Provide basic knowledge on digital signals and systems.
2. Understand the applications of Digital signal filtering techniques in smart grid.
3. Understand the application of signal processing in power systems.

Course Outcomes:
Upon completion of this course, students will be able to:
1. Understand the basic operations of signals in time domain & complex frequency domain.
2. Design digital filters for the given specifications.
3. Interpret the concepts of Multi rate digital signal processing.
4. Understand the need of signal processing in power systems.
5. Apply different filtering techniques smart grid.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	2	2	1	1
CO 2	2	2	2	1
CO 3	3	2	2	2
CO 4	3	2	1	1
CO 5	3	3	2	2

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I
Discrete Fourier Transforms: Overview of DFT- Radix-2 DIT & DIF FFT algorithms, Radix-4-Split radix FFT-Linear convolution using FFT - Overlap save & add methods.

UNIT- II
Digital filters: Review of digital filter design and structures-Basic FIR/IIR filter design and structures- Design techniques of linear phase FIR filters- IIR filters by impulse invariance-bilinear transformation - cascaded - lattice structures and parallel realization of FIR & IIR filters.

UNIT - III
Multirate DSP: Introduction - Decimator and Interpolator- Sampling rate conversion – Multistage decimator and interpolator-polyphase filters- Uniform digital filter banks.

UNIT - IV
Power Systems signals in terms of Smart Grid: Need for Signal Processing in Basics of power quality issues-

Inrush Current in Power Transformers - Over - Excitation of Transformers - Transients in Instrument Transformers - Frequency Variation - Voltage Magnitude Variations - Voltage Frequency Variations - power system protection - Wide area dynamic analysis.

UNIT - V

Filter design Applications: Adaptive IIR filters, RLS algorithms- GRLS, Gauss-Newton and RM-Basic Digital System-Parametric Notch FIR Filters-Sine and Cosine FIR Filters-Parametric Filters applications in smart grid.

Text Books:

1. J.G.Proakis,M.Salehi, "Advanced Digital Signal Processing", McGraw–Hill,1992.
2. P.F.Ribeiro, C.A.Duque, P.Marcioda Silveira and A.S. Cerqueira, "Power Systems Signal Processing for Smart Grids", 2nd Edition, John Wiley and Sons Ltd.,2014.

Suggested Reading:

1. S.Haskin, "Adaptive Filter Theory", 2nd Edition, Prentice Hall, 2001.
2. J.V.Candy, "Signal Processing: The Model Based Approach", McGraw - Hill Book Company, 1987.
3. M.H.Hayes, "Statistical Digital Signal Processing and modeling", John Wiley & Sons,1996.
4. Handouts on DSP Processors.
5. S. K.Mitra, "Digital Signal Processing –A Computer Based Approach", 2ndEdition, McGraw - Hill, 2001.

With effect from AY 2023-24

23EEE104

DIGITAL CONTROL SYSTEMS

Instruction	3 L Hours per Week
Duration of Semester End Examination	3 Hours
Semester End Examination	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge on control system

Course Objectives:

This course aims to:

1. Provide knowledge of control systems in discrete domain.
2. Provide knowledge about Z-transform and its importance in digital control.
3. Provide knowledge analyze the response of the system.

Course Outcomes:

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

1. Understand the about the digital system.
2. Analyze digital system using Z-transform.
3. Solve the state equation for discrete system.
4. Describe dynamics of digital systems
5. Design digital controller for systems for better performance.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	2	1	3	2
CO 2	2	-	3	3
CO 3	2	1	3	2
CO 4	2	-	3	2
CO 5	1	-	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I

Introduction Digital control system: Introduction: Types of signals, discrete type and continuous type control system, sampling process. Digital control systems: Forms of signal in digital control, Quantizing, Quantization error, Data acquisition, Conversion and Distribution system: Multiplexer, sample and hold circuit, analog digital converter, digital analog converter, Reconstruction of input signal by hold circuit.

UNIT - II

Z-Transform: Definition of Z-transform - Z-transforms of elementary functions: step, ramp, polynomial, exponential and sinusoidal functions, Important properties and theorems of Z-transform, Inverse Z-transform: analytical method and computational method, Z-transform method of solving different equations, numerical.

UNIT - III

Z-Plane Analysis of Discrete-Time Control Systems: Impulse sampling, Data hold: Transfer function of ZoH and first order hold , Pulse transfer function, Realization of digital controllers and digital filters, Mapping between s-plane and z-plane, Stability analysis of closed loop systems in z-plane: Jury stability test, Bi-linear transformation, Transient and steady state analyses: rise time ,delay time, peak time, peak overshoot, settling time.

UNIT - IV

State Space Analysis: Introduction of state variable model in digital control system: various canonical models. Characteristic equation and state transition matrix, Pulse transfer function matrix, Discretization of continuous time state space equations, Lyapunov stability analysis in discrete domain.

UNIT - V

Design of controller in discrete domain: Controllability, Observability, State feedback controller design: Design via pole placement. Observer Design: State observers, optimal control: Steady state quadratic optimal control, optimal controller design for servo system.

Text Books:

1. K. Ogata, "Discrete time control systems", 2nd Edition, Pearson Education, 2006.
2. M. Gopal, "Digital control engineering", 2nd Edition, New Age Int. Ltd., 2014.

Suggested Reading:

1. Ktsuhiko Ogata, "Modern control Engineering", 5th Edition, Pearson Education India, 2015.
2. B.C. Kuo, "Digital Control Systems", Oxford University Press, 2012, 2nd Edition.

NPTEL Courses:

S. No.	NPTEL Course Name	Instructor	Host Institute
1	Digital Control systems	Dr. Indrani Kar, Prof. Somnath Majhi |	IIT Roorkee

With effect from AY 2023-24

23EEE105

SMART APPLIANCES AND INTERNET OF THINGS

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge of basic programming skills, algorithm design, basics of probability & statistics

Course Objectives:
This course aims to:

1. Provide knowledge of modern domestic applications
2. Provide knowledge of IoT communication, and control technologies
3. Introducing cloud computing and applications of IoT in smart cities and electrical vehicles.

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

1. Understand and evaluate the characteristics of smart home appliances.
2. Understand the behavior of IoT and their applications.
3. Manage smart communication systems with multiple sensors and protocols.
4. Understand various cloud computing techniques.
5. Design and simulate smart homes, smart cities, and Electric Vehicles with IoTs and cloud computing.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	3	-	-	3
CO 2	3	-	-	3
CO 3	3	-	-	3
CO 4	3	2	2	3
CO 5	3	3	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I
Modern Domestic Appliances: Solid State Lamps: Introduction - Review of Light sources - white light generation techniques Characterization of LEDs for illumination application. Power LEDs- High brightness LEDs Electrical and optical properties. LED driver considerations-Power management topologies - color issues of white LEDs- Dimming of LED sources, BLDC motors for pumping and domestic fan appliances, inverter technology-based home appliances, Smart devices and equipment.

UNIT - II
IoT Communication Technologies: Introduction IoT, Sensing, Actuation, Basics of Networking, Communication Protocols, Wireless Sensor Networks, Machine-to-Machine Communications. Interoperability in IoT

UNIT - III
IoT Control Technologies and Programming: Introduction Arduino Programming, Integration of Sensors and

Actuators with Arduino, Internet of Things Open-Source Systems. Introduction Python programming, IntroductionRaspberry. Implementation of IoT with Raspberry Pi, Smart Grid Hardware Security

UNIT - IV

IoT Cloud Computation: Introduction SDN. SDN for IoT, Data Handling and Analytics, Cloud Computing, Sensor Cloud. Fog Computing,

UNIT - V

Applications of IoT: Smart Cities and Smart Homes, Electric Vehicles, Industrial IoT, Case Study: Agriculture, Healthcare, Activity Monitoring, Energy Management, Role of ML and AI in IoT

Text Books:

1. Vinod Kumar Khanna, "Fundamentals of Solid-State Lighting", 1st Edition, CRC press, 2014.
2. Chang-liang Xia, "Permanent Magnet Brushless DC Motor Drives and Controls", 1st Edition, John Wiley & Sons Singapore Pvt. Ltd., 2012.
3. K. Siozios, D. Anagnostos, D. Soudris, E. Kosmatopoulos, "IoT for Smart Grids Design Challenges and Paradigms", 1st Edition, Springer, 2019

Suggested Reading:

1. Craig Di Louie, "Advanced Lighting Controls: Energy Saving Productivity, Technology & Applications", 1st Edition, Fairmont Press, Inc., 2006.
2. Robert S Simpson, "Lighting Control: Technology and Applications", 1st Edition, Focal Press, 2003.
3. Arturas Zukauskus, Michael S. Shur & Remis Gaska, "Introduction solid state lighting", 1st Edition, Wiley- Interscience, 2002.
4. Mohan, Undeland and Robbins, "Power Electronics: Converters, Applications and Design", 1st Edition, John Wiley and Sons, 1989.

With effect from AY 2023-24

23EEE106

SMART ELECTRICAL DISTRIBUTION SYSTEM

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
Semester End Examination	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge on electrical distribution systems

Course Objectives:
This course aims to:

1. Understand the load patterns of power distribution systems.
2. Model the distribution systems components and understand the analysis methods specially developed for the distribution systems.
3. Understand the transition of conventional electrical distribution system smart electrical distribution system.

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

1. Recognize the structure and load characteristics of a power distribution system.
2. Model and analyze the smart power distribution system.
3. Analyze the distribution system power flow and short circuit studies.
4. Analyze the various functionalities of smart distribution technologies along with energy storage.
5. Follow the regulations and market models for smart distribution systems.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	2	1	3	3
CO 2	3	2	2	2
CO 3	3	3	3	2
CO 4	2	1	1	2
CO 5	3	2	2	3

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I

Introduction Smart Distribution: Fundamentals of the Electrical Power Distribution System and feeder configuration, Distribution system loading, Load Characteristics, Distribution Transformer, Single phase and three Phase Transformer connections.

UNIT - II

Distribution System Modeling: Impedance of distribution system, Modeling of distribution line, cables, Distribution Transformer, Distributed generation, loads and reactive power sources. Modeling and study of voltage regulators in distribution network

UNIT - III

Distribution System Analysis: Load flow for distribution system: Backward/forward method, Direct method, load

flow application for weakly meshed distribution system, Short Circuit analysis: Sequence based, Thevenin's Equivalent and Phase variable based, LG, LL, LLG, LLLG fault analysis and its applications.

UNIT - IV

Smart Distribution Technologies: Distribution automation, outage management systems, automated meter reading (AMR), automated metering infrastructure (AMI), Net Metering, Automated Fault Location, Isolation and Service Restoration, Outage Management Systems (OMS), Energy Storage.

UNIT - V

Regulation and Market Models for Smart Distribution Systems: Demand Response, Tariff Design, Time of the day pricing (TOD), Time of use pricing (TOU), Consumer privacy and data protection, consumer engagement etc. Cost benefit analysis of smart grid projects.

Text Books:

1. A.S. Pabla, "Electric Power Distribution", 4th Edition, Tata McGraw Hill Publishing Co. Ltd., 2017.
2. Abdelhay A. Sallam and Om P. Malik, "Electric Distribution Systems", 2nd Edition, IEEE Press Series, 2019.

Suggested Reading:

1. W. H. Kersting, "Distribution System Modeling and Analysis", 4th Edition, CRC Press, 2017.
2. D. John, "Electric Power Substations Engineering", 3rd Edition, McDonald (Editor), CRC Press, 2016.

With effect from AY 2023-24

23EEE107

MODELING AND ANALYSIS OF RENEWABLE ENERGY SOURCES

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge of renewable energy resources

Course Objectives:

This course aims to:

1. Understand the design and modelling of renewable energy resources.
2. Understand the operation of renewable energy resources.
3. Design modern control technologies for microgrids in Islanded and grid connected operation.

Course Outcomes:

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

1. Apply new techniques for modelling of PV, Wind and Fuel cell.
2. Develop new tracking techniques and reconfiguration methods for PV and power enhancement of Wind and PV systems.
3. Understanding of the microgrid types and configurations
4. Understand the energy management concept in a grid connected and islanded microgrid.
5. Understand the necessity and functioning of Hybrid Energy storage systems.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	2	2	1	2
CO 2	3	2	2	2
CO 3	3	3	2	2
CO 4	2	3	2	2
CO 5	3	3	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I

Solar Energy: Principle of direct solar energy conversion in electricity in a solar cell - properties - Solar cell and its types - p-n junction, structure- I- V characteristics of a PV module - solar PV modelling and equations - modelling techniques - cell efficiency - fill factor - Applications.

UNIT - II

Maximum power point tracking: Need for Maximum power tracking - effect of irradiation and temperature on PV characteristics – Partial Shading - Tracking techniques and solar PV array reconfiguration. Standalone and grid interactive systems.

UNIT – III

Wind Energy: Wind speed and power relation, power extracted from wind, wind distribution and wind speed predictions. Wind power systems: system components, Types of Turbines, Turbine rating. Choice of generators, turbine rating, electrical load matching, Variable speed operation, Modelling of Wind generator, maximum power operation. design features, standalone wind system.

UNIT - IV

Fuel Cell: Fuel cell definition, difference between batteries and fuel cells, fuel cell components, principle and working of fuel cell, performance characteristics, efficiency, fuel cell stack, fuel cell power plant: fuel processor, fuel cell power section, power conditioner, Advantages and disadvantages, Mathematical Modelling of Fuel cell system for standalone application.

UNIT - V

Grid Integration: Microgrid Configurations – CERTS Microgrid Test Bed – DC Microgrid- HFAC Microgrid – LFAC Microgrid – Hybrid DC- and AC- Coupled Microgrid - Grid Connected Mode – Islanded mode – Battery Charging mode – design of power converters– Brick Busses Software Framework- Multi Function grid Connected inverters.

Text Books:

1. Ali Keyhani Mohammad Marwali and Min Dai, "Integration and Control of Renewable Energy in Electric Power System" John Wiley publishing company
2. S. Chowdhury, S. P. Chowdhury, P. Crossley, "Microgrids and Active Distribution Networks", IET Power Electronics Series, 2012
3. Suleiman M,Sharkh, Mohammad A.Abu-Sara Georgios I. Orfanoudakis, Babar Hussain, "Power Electronic Converters for Microgrid", Wiley- IEEE Press, 2014

Suggested Reading:

1. Quing-Chang Zhong, "Control of Power Inverters in Renewable Energy and Smart Grid Integration", Wiley, IEEE Press
2. Bin Wu, Yongqiang Lang, Navid Zargari, "Power Conversion and Control of Wind Energy Systems", Wiley 2011.
3. Nikos Hatziargyiou, "Microgrids: Architectures and Control" ISBN: 978-1-118-72068- 4, Wiley- IEEE Press, December 2013.
4. S.Chowhury, S.P.Chowdury and Peter Crossley, "Microgrids and Active Distribution Networks" ISBN 978-1-84919-014-5, IET renewable Energy series, 2011.

With effect from AY 2023-24

23EEE108

ADVANCED ELECTRIC DRIVES

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
Semester End Examination	60 Marks
CIE	40 Marks
Credits	3

Pre requisite: Students should have prior knowledge of Electrical Machines

Course Objectives:
This course aims to:

1. Understand the concept of advanced modelling and control of machines.
2. Understand the concept of axis transformation and modeling and control aspects of DC motors, Induction motors and Conventional Synchronous Motors.
3. Study the working principles and control aspects of special motors: Brushless DC motor, Switched Reluctance Motor drives, Permanent Magnet Syn. Motor, Syn. Reluctance Motor, and Stepper Motor.

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

1. Identify the need of linear transformation and illustrate the DC motor speed control.
2. Illustrate the concept of modeling and speed sensor-less control of Induction machine in dq0 frame.
3. Analyze how independently control the torque and flux of Induction motor without the need of Axis transformation.
4. Explore the concept of Synchronous motor modeling and control.
5. Explore the Control of special motor drives.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	2	3	1	1
CO 2	3	3	2	3
CO 3	3	3	2	2
CO 4	3	2	2	2
CO 5	3	3	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I

Elements of Generalized theory of Electrical Machines: Generalized theory and Kron's primitive machine model; Reference frame theory.

DC Drive: Modeling of Separately excited DC machine, Series DC machine, Effect of shifting of brush Axis, Review of Controllers, Speed control of a separately excited DC drive with inner current loop and outer speed loop.

UNIT - II

Asynchronous Machine Drive- I: Scalar Control versus Vector Control, vector control of induction motor: Principles of vector control, Direct vector control, Indirect vector control, implementation – block diagram; estimation of flux, flux weakening operation. Sensorless vector control of induction motor: Estimation techniques.

UNIT - III

Asynchronous Machine Drive- II: Direct Torque Control of Induction Motor Drives, Space Phasor representation, Flux and torque control, Switching implementation, Sensorless operation.

UNIT - IV

Synchronous Machine Drive- I: Control of synchronous motor drives: Structure-Stator Excitation-techniques of sensor less operation-convertor topologies- Waveforms- drive design factors-Torque controlled synchronous motor drives-Torque Ripple- Instantaneous Torque control -using current controllers-flux controllers.

UNIT - V

Synchronous Machine Drive- II: Control of Special Machines: Principle of operation of PMSM and BLDC, Stepper Motors, Switched Reluctance Motors and Synchronous Reluctance motors.

Text Books:

1. P. C. Krause, O. Wasynczuk, and S. D. Sudhoff, "Analysis of Electric Machinery", McGraw Hill Book Company.
2. B. K. Bose, "Power Electronics and AC Drives", Prentice Hall, 2002.
3. Bin Wu, "High-Power Converters and AC Drives", John Wiley and Sons, 2006.

Suggested Reading:

1. R. Krishnan, "Electric Motor Drive: Modeling, Analysis and Control", Prentice Hall of India, 2001.
2. P. S. Bimbra, "Generalized theory of Electrical Machines", Khanna Publication, 2006.
3. H. Abu Rub, A. Iqbal, J. Guzinski, "High Performance Control of AC Drives With MATLAB/Simulink Models", John Wiley and Sons, 2012.

NPTEL Courses:

S.No.	NPTEL Course Name	Instructor	Host Institute
1	Advanced Electric Drives	Dr. S.P. Das	IIT Kanpur
2	Modelling and Analysis of Electric Machines	Dr. KrishnaVasudevan	IIT Madras

With effect from AY 2023-24

23EEE109

DISTRIBUTION SYSTEM PLANNING AND AUTOMATION

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Should have basic knowledge in power system transmission and power system analysis.

Course Objectives:

This course aims to:

1. Study sub-transmission, Distribution substations
2. Understand the philosophy of Distribution Automation and SCADA
3. Explore the reforms in the power systems.

Course Outcomes:

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

1. Acquire knowledge of sub-transmission, Distribution substations
2. Analyze primary and secondary distribution systems.
3. Find the voltage regulation and impact of capacitors in the distribution systems.
4. Explain the concept of reforms in power sector & demonstrate the need and functioning of SCADA system.
5. Understand the concept of substation metering and its revenue generation.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	3	1	3	3
CO 2	3	1	2	3
CO 3	3	1	3	2
CO 4	3	1	2	3
CO 5	3	1	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I

Sub-Transmission Lines & Substations: Types of sub transmission, Distribution substation, Bus schemes, Substation location, Rating of substation, Calculation of voltage drops with primary feeders, Derivation of the K constant, Application curves, Interpretation of the Percentage Voltage drop formula.

UNIT - II

Primary Feeders: Types of primary feeders, Primary feeder loading, Tie lines, Design of radial primary feeders, Voltage drop calculations by ABCD constants, uniformly distributed load, Non uniformly distributed load, Distribution Feeder Analysis

Secondary Feeders: Secondary voltage levels, Present design practice, Secondary Banking, Economic design of secondaries, Total annual cost equation.

UNIT - III

Distribution voltage regulation: Three-phase balanced and non-three-phase primary lines, analysis distribution and equipment costs, introduction Distribution system voltage regulation, voltage standards, voltage control, feeder-Voltage regulators, line-drop compensation, Capacitors in Distribution Systems: Effects of series and shunt capacitors – justification for capacitors – Procedure determine optimum capacitor size and location.

UNIT - IV

Distribution System Automation: Reforms in power sector – Methods of improvement – Reconfiguration – Automation – Communication systems – Sensors –Basic architecture of Distribution automation system – software and open architecture – RTU and Data communication – SCADA requirement and application functions – Communication media for distribution system automation- Communication protocols for Distribution systems – IEC 61850 and IEEE 802.3 standards

UNIT - V

Distribution system management: Integrated sub–station metering system – Revenue improvement – issues in multi–year tariff and availability-based tariff.

Text Books:

1. Turan Gonen, "Electric Power Distribution System Engineering", 2nd Edition, CRC Press, 2008.
2. A.S. Pabla, "Electric Power Distribution", 5th Edition, Tata McGraw Hill Publishing Co. Ltd, 2004.

Suggested Reading:

1. M.K. Khedkar, G.M. Dhole, "A Text Book of Electric power Distribution Automation", University Science Press, New Delhi,2010
2. Anthony J Pansini, "Electrical Distribution Engineering", CRC Press, 1992
3. James Momoh, "Electric Power Distribution, automation, protection & control", CRC Press, 2007

With effect from AY 2023-24

23EEE110

MACHINE LEARNING AND APPLICATIONS

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge of basic programming skills, algorithm design, basics of probability & statistics

Course Objectives:
This course aims to:
1. Understand the basics of Machine Learning
2. Apply different machine learning models to various datasets.
3. Introduce advanced concepts and methods of machine learning.

Course Outcomes:
Upon completion of this course, students will be able to:
1. Understand basic concepts of Machine Learning Techniques
2. Understand the different types of datasets.
3. Develop skills in using machine learning algorithms for solving practical problems.
4. Analyze and work with different datasets.
5. Apply Machine Learning Algorithms for Electrical Engineering problems.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	3	-	-	2
CO 2	3	-	-	2
CO 3	3	-	-	3
CO 4	3	2	2	3
CO 5	3	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I
Introduction Machine Learning (ML): Introduction, Definitions, Types of Learning, Data Representation, Hypothesis space, Inductive Bias, Evaluation, Training and test set, cross- Validation, Applications of ML.

UNIT - II
Supervised Learning: Classification and Regression: Linear Regression, Logistic Regression, Classification, Naive Bayes Classifiers, K-Nearest Neighbor (K-NN), Decision Trees, Support Vector Machine (SVM), Overfitting, Advantages and Disadvantages of supervisory learning.

UNIT - III
Unsupervised Learning: Introduction clustering, Types of Clustering: K-means clustering, Classifier, Hierarchal clustering, Gaussian mixture model, Association, Advantages and Disadvantages of Unsupervised learning, Difference between Supervised and Unsupervised Learning.

UNIT - IV
Dimensionality Reduction Techniques: Principal Component Analysis (PCA), Latent Dirichlet Allocation (LDA),

Independent Component Analysis (ICA), Introduction Deep Learning.

UNIT - V

Applications of ML: Load Forecasting – Energy Market forecasting – Fault identification and localization- Renewable Uncertainty estimation

Text Books:

1. Tom Mitchell, “Machine Learning”, First Edition, McGraw- Hill, 1997.
2. Ethem Alpaydin, “Introduction Machine Learning”, Edition 2.
3. M.Gopal, “Applied Machine Learning”, McGraw Hill Education (India) Private Limited, 2018
4. Andreas C. Mueller and Sarah Guido, “Introduction Machine Learning with Python”, O'Reilly Media, Inc, 2016
5. Christopher Bishop, “Pattern Recognition and Machine Learning”, Springer, 2011

Suggested Reading:

1. Jeeva Jose, “Introduction Machine Learning”, Khanna Book Publishing Co., 2020.
2. John Paul Mueller and Luca Massaron, “Machine Learning for Dummies”, 2016.
3. Rajeev Chopra, “Machine Learning”, Khanna Book Publishing Co., 2021
4. Ethem Alpaydin, “Machine Learning: The New AI”, The MIT Press, 2016

NPTEL/SWAYAM Course:

S.No	NPTEL Course Name	Instructor	Host Institute
1	Introduction Machine Learning	Prof. Balaraman Ravindran	IIT Madras
2	Introduction Machine Learning - IITKGP	Prof. Sudeshna Sarkar	IIT Kharagpur
3	Machine Learning	Prof. Carl Gustaf Jansson	KTH, The Royal Institute of Technology

With effect from AY 2023-24

23EEE111

POWER QUALITY IMPROVEMENT TECHNIQUES

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge of power systems

Course Objectives:

This course aims to:

1. Understand the theoretical concepts and standards of Power Quality (PQ), and methods calculate and analyze voltage sag in distribution systems.
2. Have knowledge of Analysis of Voltage Sag
3. Understand PQ issues and sources of harmonics in Industrial systems and its mitigation.

Course Outcomes:

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

1. Know how to measure and analyze power quality issues.
2. Analyze and understand power system harmonics.
3. Analyze distribution system voltage sag by acquiring the necessary knowledge.
4. Understand Harmonic Filtering Techniques.
5. Understand power factor correction, wiring and grounding problems.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	3	-	3	3
CO 2	3	-	3	2
CO 3	3	-	2	3
CO 4	3	-	2	3
CO 5	3	-	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I

Introduction Power Quality: Overview of power quality phenomena, voltage quality, classification of power quality issues, Power quality measures and standards-THD-TIF-DIN-C-message weights. Flicker factor, transient phenomena-occurrence of power quality problems, Power acceptability curves- PQ Measuring Instruments. Standards and recommended practices

UNIT - II

Harmonics: Harmonic distortion and solutions, Voltage distortion Vs Current distortion, Sources of harmonics, Effect of harmonic distortion, Impact of capacitors, transformers and motors, harmonic sources from commercial and industrial loads, locating harmonic sources of power system.

UNIT - III

Voltage Sag Analysis: Voltage sag Analysis causes and sources of voltage sags, voltage flow chart, voltage sag magnitude and duration plots, fast assessment methods for voltage sags in distribution systems, effect of momentary voltage dips on the operation of Induction motor and Synchronous Motors.

UNIT - IV

Harmonic Filtering: Passive Harmonic Filtering, Three Phase Three-wire Shunt Active Filtering and their control using p-q theory and d-q modeling, Hybrid Filtering using Shunt Active Filters, Dynamic Voltage Restorer and its control, Power Quality Conditioner,

UNIT - V

PQ Consideration in Industrial Power Systems: Adjustable speed Drives and its applications, Reasons for grounding, typical wiring and grounding problems-solutions.

Power Factor Correction: Control Methods for Single Phase APFC, Three Phase APFC and Control Techniques

Text Books:

1. G.T. Heydt, "Electric power quality", McGraw-Hill Professional, 2007
2. Math H. Bollen, "Understanding Power Quality Problems", IEEE Press, 2000
3. C.Sankaran, 'Power Quality', CRC Press, 2001

Suggested Reading:

1. J. Arrillaga, "Power System Quality Assessment", John wiley, 2000
2. J. Arrillaga, B.C. Smith, N.R. Watson & A. R.Wood ,"Power system Harmonic Analysis", Wiley, 1997
3. Roger C.Dugan, Mark F.McGranaghan, Surya Santoso, H.Wayne Beaty, 'Electrical Power Systems Quality', 3rd Edition,Tata McGraw-Hill, 2012.
4. R.Sastry Vedam, M.Sarma, "Power Quality- Var Compensation in Power Systems ", CRC Press, 2009

Online Resourses:

1. https://onlinecourses.nptel.ac.in/noc23_ee63/preview
2. https://onlinecourses.nptel.ac.in/noc23_ee27/preview

NPTEL Courses:

S.No.	NPTEL Course Name	Instructor	Host Institute
1	Power Quality	Prof. Bhim Singh	IIT Delhi
2	Power Quality Improvement Technique	By Prof. Avik Bhattacharya	IIT Roorkee

With effect from AY 2023-24

23EEE112

HIGH POWER INVERTERS

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have an introductory course on Power Electronics.

Course Objectives:
This course aims to:
1. Understand the importance of multilevel inverters.
2. Figure out different topologies of MLIs.
3. Know different PWM control techniques for inverters.

Course Outcomes:
Upon completion of this course, students will be able to:
1. Understand the basic operation and drawback of two-level inverters and the necessity of MLI and basic topologies.
2. Implement the operation of DCMLI and implement level-shifted, phase shifted and space vector PWM.
3. Differentiate between symmetrical and asymmetrical cascaded MLI and understand different topologies of MMI.
4. Comprehend reduced switch count MLIs with different topologies.
5. Identify PWM in current source inverters.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	3	1	2	-
CO 2	3	1	2	-
CO 3	3	1	2	-
CO 4	3	1	2	-
CO 5	3	1	2	-

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I:
Introduction: Review of two-level inverters and their PWM schemes. Effect of dead-time and compensation in two-level inverters. Limitations of two-level inverters and introduction multilevel inverters. Conventional multilevel inverter topologies.

UNIT - II
Diode clamped multilevel inverter (DCMLI**):** Three, Four and Five level DCMLIs, level shifted PWM, Neutral point voltage balance, SVM and discontinuous SVM, Elimination of common mode voltage, Active Neutral Point Clamped Inverter (ANPCI).

UNIT - III
Cascade H-bridge (CHB) multilevel inverter (MLI): Symmetrical and asymmetrical topologies, level-shifted PWM, phase-shifted PWM, hybrid PWM and SVM. Concept of coupling transformer less grid connected applications, Topologies of modular multilevel inverters (MMI).

UNIT - IV

Reduced switch count MLIs: Introduction, classification, operation of T-type, multilevel dc link, switched series-parallel source and other topologies.

UNIT - V

PWM current source inverters: Trapezoidal modulation, selective harmonic elimination and SVM, Load-commutated inverters (LCI).

Text Books:

1. Bin Wu, "High Power Converters and AC Drives", 2nd Edition, Wiley- Inter science, 2017.
2. D. Grahame Holmes and Thomas A. Lipo, "Pulse Width Modulation for Power Converters: Principles and Practice", IEEE Press, 2003.

Suggested Reading:

1. N. Mohan, T. M. Undeland and W.P Robins, "Power Electronics Converters, Application and Design", 3rd Edition, John Wiley India 2003.
2. M. H. Rashid, "Power Electronics Circuits, Devices and Applications", 3rd Edition, Prentice-Hall 2004.
3. L. Umanand, "Power Electronics Essentials and Applications", Wiley India 2009.

NPTEL Courses:

S.No.	NPTEL Course Name	Instructor	Host Institute
1	High Power Multi-Level Converters, Analysis, Design and Operational Issues	Prof. Anandarup Das	IIT, Delhi

With effect from AY 2023-24

23EEE113
INDUSTRIAL AND STRATEGIC APPLICATIONS OF SUPERCONDUCTIVITY

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge on Basic Electrical Engineering.

Course Objectives:
This course aims to:
1. Understand the fundamentals of superconductivity.
2. Examine the applications of superconductivity.
3. Evaluate the emerging trends and prospects.

Course Outcomes:
Upon completion of this course, students will be able to:
1. Develop an understanding of the fundamental principles of superconductivity, including the properties of superconducting materials, critical temperature, and Meissner effect.
2. Analyse the potential applications of superconductivity in various industries, including energy, transportation, medical imaging, and computing.
3. Evaluate the benefits and limitations of superconductivity, including the technical, economic, and societal challenges that must be addressed for widespread adoption.
4. Apply the strategic implications of superconductivity, including its potential impact on national security, global competition, and intellectual property.
5. Explore the emerging trends in superconductivity research and development and assess the potential for future breakthroughs and new applications.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	3	3	2	2
CO 2	3	3	2	2
CO 3	3	3	3	3
CO 4	3	3	3	2
CO 5	3	3	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I

Introduction: Physics of superconductivity: Discovery of superconductivity. Meissner state, Superconductors vs. perfect conductors, Basic Research need for superconductivity. Cryostat and Experimental Set-up for testing Superconductivity

Theories of superconductivity: London, Ginzburg-Landau, BCS, Phase diagrams, mixed state, type- I and type- II superconductors, flux flow and flux creep.

UNIT - II

Types of Superconducting Materials: Low-temperature superconductors (NbTi, Nb3Sn). Wire manufacturing, physical properties, BJT Diagram High-temperature superconductors (BSCCO, YBCO). Bulk, tapes and wires, physical properties, BJT Diagram Manufacturer of Superconducting wire for various applications.

Stability and AC Losses: Degradation, training, and Stability criteria. Different losses in superconductors - hysteresis, eddy current, coupling losses.

UNIT - III

Medical and power system applications: Overview of energy and medical applications of superconductors: Introduction MRI magnets, Design Aspects of MRI Magnets, Functioning of MRI Magnets, Application in Power system: Fault current limiters- Schematic Diagram and Principle of Operation., Resistive type and Inductive type Fault current Limiters. SC Transformers, Advantages, Construction and operational Aspects. SC Cables and its Application, Superconducting Magnetic Energy Storage System (SMES) and its application for power system stability.

UNIT - IV

Industrial and Strategic applications: Overview of Industrial and Strategic energy applications of superconductors, Superconducting Motors and Wind Generators, Design Aspects, Air gap Electromagnetic Field calculation, Manufacture and Performance Evaluation. Application of SC Degaussing Coils for Naval Ships, Schematic diagram and Application for SC Magnets for Maglev Trains.

UNIT –V

Accelerator Fusion Magnet: Introduction, Advance applications-particle accelerators Research being carried out at International thermonuclear Experimental Reactor (ITER), France Facility for Antiproton and Ion Research in Europe GmbH" (FAIR GmbH).

Text Books:

1. Michael Tinkham, “Introduction Superconductivity”, Second Edition.
2. Stephen J. Blundell, “Superconductivity: A Very Short Introduction”
3. Edited by Paul Seidel, “Applied Superconductivity: Handbook on Devices and Applications”
4. Edited by P. Seidel and H.W. Weber, “Superconductivity: Fundamentals and Applications”
5. Martin N. Wilson A “Superconducting Magnets” Clarendon Press Publication
6. J. R. Bumby, “Superconducting Rotating Electrical Machines” Clarendon Press
7. Peter Schmueser, Siegfried Wolff, “Superconducting Accelerator Magnets Karl-hubert Mess”.

Suggested Reading

1. J. Robert Schrieffer and Leon N. Cooper, "High-Temperature Superconductivity: An Introduction"
2. James F. Annett, "Superconductivity, Super fluids, and Condensates"
3. Rolf W. Grosse and Werner Kissener, "Superconductivity: Basics and Applications Magnets”.
4. YuAshida, "Superconductivity: A New Approach Based on the Bethe–Salpeter Equation in the Mean-Field Approximation".
5. Vernon L., “Applied Superconductivity: Volume 2”, Academic Press - Technology Engineering pages.

With effect from AY 2023-24

23EEE114

MODERN CONTROL THEORY

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge of Control System

Course Objectives:
This course aims to:
1. Model a control system in state space and test its controllability and observability.
2. Provide knowledge of the state space model of the control system.
3. Understand the non-linear systems behavior and the methods determine their stability.

Course Outcomes:
Upon completion of this course, students will be able to:
1. Develop a state space model of physical systems.
2. Solve the state equation.
3. Design controller and observer for the linear system.
4. Analyze the stability of linear and nonlinear systems.
5. Formulate and solve optimal control problems.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	2	1	3	2
CO 2	2	-	3	2
CO 3	2	1	3	3
CO 4	2	-	3	2
CO 5	1	-	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I
State Space System Representation: Concept of state, state and output equation, state models for dynamic system, non-uniqueness of state model, State model transfer function representation, Various canonical forms, plant model representation using state function.

UNIT - II
Solution of State Equations: Concept of Eigenvalue and Eigenvectors, State transition matrix, Properties of state transition matrix, methods of evaluation: similarity transformation, Cayley Hemilton method, Inverse Laplace method. Time response of linear systems -State diagrams.

UNIT - III
Controllability and Observability: Definition and general concepts, Controllability and observability test for linear time invariant systems, controller and observer design: State variable feedback controller, full order observer, and reduced order observer.

UNIT - IV

Stability: Concept of stability: BIBO stability, zero input stability, equilibrium points. Lyapunovs stability: stability in the sense of Lyapunov, Lyapunov stability theorem, Lyapunovs instability theorem. direct methods of Lyapunov, use of Luapunov function estimate transients, stability of nonlinear systems, formation of Lyapunov function for linear and nonlinear systems.

UNIT - V

Optimal Control: Formulation of the optimal control problem: minimum time, minimum fuel, minimum energy, state regulator problem, tracking problem. Calculus of variations: formulation of various calculus using Hamiltonian method, Pontryagin's minimum principle. Optimal control problem: Hamilton Jacobi approach, Riccati equation. State variable feedback design.

Text Books:

1. M. Gopal, "Modern Control Systems Theory", 3rd Edition, New Age International Private Limited, 2014.
2. Katsuhiko Ogata, "Modern control Engineering", 5th Edition, Pearson Education India, 2015.

Suggested Reading:

1. Z. Bubnicki, "Modern Control Theory", 1st Edition, Springer, 2010.
2. Schultz & Melsa, "State functions & linear control systems", McGraw Hill Book Co. New York, 1998.

NPTEL/SWAYAM Course:

S. No.	NPTEL Course Name	Instructor	Host Institute
1	Dynamical System and Control	Prof. N. Sukavanam, Prof. D. N. Pandey	IIT Roorkee

With effect from AY 2023-24

23EEE115

SMART GRID TECHNOLOGIES

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge on conventional power grid operations and communication.

Course Objectives:

This course aims to:

1. Understand the concept of smart grid and its advantages and the operation of smart devices such as PMU, IED etc.
2. Know smart metering techniques and wide area measurement techniques.
3. Understand the operation of micro grid and its components and the problems associated with integration of distributed generation.

Course Outcomes:

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

1. Identify the difference between smart grid & conventional grid.
2. Demonstrate the role of smart devices such as PMU, IED etc. in Smart Grid
3. Understand the role of SCADA in Smart grid controlling and data acquisition.
4. Analyze the operation and control of Micro Grid.
5. Choose the suitable modern communication technologies for the required smart grid operation

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	2	2	3	2
CO 2	2	2	3	2
CO 3	2	2	3	2
CO 4	2	2	3	2
CO 5	1	2	2	1

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I

Introduction Smart Grid: Working definitions of Smart Grid, Traditional Power Grid and Smart Grid, New Technologies for Smart Grid, Drivers for Smart Grid, Smart Grid Functionalities and Key components, Key Challenges for Smart Grid, Smart Grid Initiatives in India, International policies and standards in Smart Grid

UNIT - II

SCADA: Supervisory control and data acquisition (SCADA) systems, Components of SCADA systems, SCADA applications, SCADA basic functions, SCADA application functions, Advantages of SCADA in power systems

UNIT - III

Smart Systems: Real Time Prizing, Automatic Meter Reading (AMR), Geographic Information System (GIS), Outage Management System (OMS), Home and Building Automation, Smart Substations, Vehicle Grid

Smart Devices: Smart Meters, Smart Sensors, Smart Appliances, Intelligent Electronic Devices (IED) Phase Measurement UNIT -(PMU), Remote terminal UNIT -(RTU) and their application for monitoring & protection.

UNIT - IV

Micro-Grid: Microgrid Concept, Microgrid Architecture, Issues of interconnection, Operation and Control of Microgrids, Protection of micro-grid, Integration of DG and DS in a Microgrid, Operating Problems in Microgirds, applications of micro-grid, Introduction DC Microgrids

UNIT - V

Communication Systems: Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighborhood Area Network (NAN), Wide Area Network (WAN), Bluetooth, ZigBee, GPS, Basics of CLOUD computing and its necessity in Smart Grids, Cyber Physical Attacks and Security for Smart Grid, Smart grid Logical Security Architecture, Broadband over Power line (BPL). IP based protocols.

Text Books:

1. Ali Keyhani, "Design of smart power grid renewable energy systems", Wiley IEEE, 2011.
2. Clark W. Gellings, "The Smart Grid: Enabling Energy Efficiency and Demand Response", CRC Press.
3. Padiyar, K. R., & Kulkarni, A. M." Dynamics and control of electric transmission and microgrids". John Wiley & Sons, 2019.
4. Thomas, M. S., & McDonald, J. D." Power system SCADA and smart grids". CRC press, 2017.

Suggested Reading:

1. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, "Smart Grid: Technology and Applications", Wiley 2012.
2. Stuart Borlas'e, "Smart Grid:Infrastructure, Technology and solutions" CRC Press.
3. A.G.Phadke , "Synchronized Phasor Measurement and their Applications", Springer.

NPTEL Course:

S.No.	Course Name	Instructor Name	Host Institute
1	Smart Grid: Basics Advanced Technologies	Prof. N. P. Padhy& Prof. Premalata Jena.	IIT Roorkee

With effect from AY 2023-24

23EEE116

POWER SYSTEM DYNAMICS

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge of Power Systems and its Operation and Control

Course Objectives:

This course aims to:

1. Understand and analyze the various stability concepts of the power system.
2. Study the concept of modeling synchronous machines.
3. Understand the phenomenon of SSR oscillations in power systems.

Course Outcomes:

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

1. Distinguish various stabilities issues in the power system.
2. Understand the modeling of synchronous machines.
3. Describe the role of Excitation, PSS and Prime Movers in improving the power system performance during disturbances.
4. Analyze the small-signal stability of the power system.
5. Infer the concepts of LFOs and SSR in detail.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	1	1	2	1
CO 2	1	1	2	1
CO 3	1	1	2	1
CO 4	1	1	2	1
CO 5	1	1	2	1

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I

Synchronous Machine Modeling: Introduction, Park's Transformation, Flux Linkage Equations, Voltage Equations, Formulation of State-Space Equations, Current Formulation, Per UNIT -Conversion, Normalized Voltage and Torque Equations, Torque and Power, Equivalent Circuit of a Synchronous Machine, Flux Linkage State-Space Model

UNIT - II

Stability: Definitions classification of stability, Analysis of Steady state stability, Factors affecting Steady state stability, Transient stability, Equal-area criterion, Factor influencing Transient stability, Numerical Methods for analyzing transient stability, Definition of voltage stability, voltage security, voltage collapse, Factors contributing and affecting voltage stability and minimization of voltage collapse, analysis of voltage stability/collapse, P- V and Q- V curves

UNIT - III

System Performance Improvement: Excitation Systems**:** Requirements, elements of excitation systems, types of excitation systems, modeling of excitation systems

Power system stabilizers: Basic concepts in applying PSS, Structure and tuning of PSS.
Load models: Concept of load modeling, static and dynamic load models
Prime Movers: Hydraulic turbine and governing systems, steam turbine and governing system

UNIT - IV
Small-signal stability: Fundamentals of stability of dynamic systems, Modal matrices, free motion of dynamic systems, mode shapes, small-signal analysis of SMIB, synchronizing and damping torque analysis, state equations for small-signal model.

UNIT - V
Sub-Synchronous Oscillations: Turbine-generator torsional characteristics, Torsional interactions with power system controls, Sub-Synchronous Resonance (SSR), countermeasures for SSR

Text Books:

1. P. M. Anderson & A. A. Fouad "Power System Control and Stability", Wiley & Sons, 2003
2. P. Kundur, "Power System Stability and Control", McGraw Hill Inc, 1994
3. K R Padiyar," power system dynamics: stability and control", BS Publications, 2008

Suggested Reading:

1. J Machowski, J Bialek& J. R W. Bumby, "Power System Dynamics and Stability", John Wiley & Sons, 1997
2. L. Leonard Grigsby (Ed.); "Power System Stability and Control", Second edition, CRC Press,2007

NPTEL Courses:

S.No.	NPTEL Course Name	Instructor	Host Institute
1	Power Quality	Prof. Bhim Singh	IIT Delhi

With effect from AY 2023-24

23EEE117

POWER ELECTRONICS FOR POWER SYSTEMS

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge on Power Electronics and Power System Control.

Course Objectives:

This course aims to:

1. Introduce the concepts of reactive power compensation that can be used for interconnected power transmission and distribution systems.
2. Study the principles of operation and control of shunt, series and combined FACTS controllers.
3. Study the various types of power quality problems in distribution systems and know about the filters.

Course Outcomes:

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

1. Distinguish the performance of Transmission line with and without FACTS Devices
2. Compare the SVC and STATCOM.
3. Understand the operation and control of various Static Series Compensators
4. Understand the operation and control of Unified Power Flow Controller
5. Distinguish various power quality issues and how they are mitigated by various FACTS Devices

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	2	2	3	2
CO 2	2	2	3	2
CO 3	2	2	3	2
CO 4	2	2	3	2
CO 5	1	2	2	1

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I

Reactive Power Flow Control in Power Systems: Power flow control, Constraints of maximum transmission line loading, Benefits of FACTS Transmission line compensation, Uncompensated line, Shunt compensation, Series compensation, Phase angle control, Reactive power compensation, Shunt and Series compensation principles, Reactive compensation at transmission and distribution level.

UNIT - II

Static Shunt Compensation: Static versus passive VAR compensator, Static shunt compensators, SVC and STATCOM, Operation and control of TSC, TCR and STATCOM Compensator control, Comparison between SVC and STATCOM.

UNIT - III

Static Series Compensation: TSSC, SSSC -Static voltage and phase angle regulators, TCVR and TCPAR Operation and Control, Applications, Static series compensation, GCSC, TSSC, TCSC and Static synchronous series

compensators and their Control.

UNIT - IV

Combined Power Flow Controller: Circuit Arrangement, Operation and control of UPFC, Basic Principle of P and Q control, Independent real and reactive power flow control- Applications, Introduction interline power flow controller (IPFC)

UNIT - V

Power Quality Problems in Distribution Systems: Harmonics, loads that create harmonics, harmonic propagation, series and parallel resonances, mitigation of harmonics, passive filters, active filter, shunt, series, hybrid filters and their control. Voltage swells, sags, flicker, unbalance and mitigation of these problems by unified power quality conditioner (UPQC), IEEE standards on power quality.

Text Books:

1. K R Padiyar, "FACTS Controllers in Power Transmission and Distribution", New Age International Publishers, 2007.
2. N.G. Hingorani, L. Gyugyi, "Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems", IEEE Press Book, Standard Publishers and Distributors, Delhi, 2001.

Suggested Reading:

1. X P Zhang, C Rehtanz, B Pal, "Flexible AC Transmission Systems- Modelling and Control", Springer Verlag, Berlin 2006.
2. K.S.Sureshkumar, S.Ashok , "FACTS Controllers & Applications", E-book edition, Nalanda Digital Library, NIT Calicut, 2003.
3. G. T. Heydt, "Power Quality", McGraw-Hill Professional, 2007.
4. T. J. E. Miller, "Static Reactive Power Compensation", John Wiley and Sons, New York, 1982

NPTEL Courses:

S.No.	NPTEL Course Name	Instructor	Host Institute
1	Facts Devices	Prof. Avik Bhattacharya	IIT Roorkee

With effect from AY 2023-24

23EEE118

CONTROL AND INTEGRATION OF RENEWABLE ENERGY SOURCES

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Pre requisite: Students should have prior knowledge of the Power System and Control System.

Course Objectives:
This course aims to:
1. Provide the knowledge of grid configuration for renewable energy.
2. Provide the knowledge analyze model of renewable energy sources and storage devices.
3. Provide the knowledge analyze control mechanism for grid connected and off-grid systems.

Course Outcomes:
Upon completion of this course, students will be able to:
1. Understand different renewable energy sources and storage devices.
2. Modelling of renewable energy sources.
3. Analyze and simulate control strategies for grid connected and off-grid systems.
4. Understand the control issues and challenges.
5. Understand the standards for renewable energy grid integrations.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	-	2	3	1
CO 2	-	2	3	2
CO 3	3	2	3	3
CO 4	3	2	3	3
CO 5	3	2	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I
Introduction: Electric grid, power quality, stability and cost, importance &amp, effects of renewable energy penetration in the grid, boundaries of the actual grid configuration, consumption models and patterns.

UNIT - II
Dynamic Energy Conversion Technologies: Introduction, types of conventional and nonconventional dynamic generation technologies, principle of operation and analysis of reciprocating engines, gas and micro turbines, hydro and wind-based generation technologies.

UNIT - III
Static Energy Conversion Technologies: Introduction, types of conventional and nonconventional static generation technologies, principle of operation and analysis of fuel cell, photovoltaic systems and wind generation technologies, storage technologies - batteries, fly wheels, super capacitors and ultra-capacitors.

UNIT - IV

Control Issues and Challenges: Predictive controllers and adaptive controllers, load frequency and voltage control. modulation techniques, control of diesel, pv, wind and fuel cell-based generators, dimensioning of filters, fault-ride through capabilities.

UNIT - V

Integration of Energy Conversion Technologies: Introduction &amp, importance of integrated systems, Interfacing requirements. IEEE & IEC codes and standards for renewable energy grid integrations.

Text Books:

1. G. Masters, "Renewable and Efficient Electric Power Systems", 2nd Edition, G. Masters, IEEE-John Wiley and Sons Ltd. Publishers, 2013.
2. S. Chowdhury, S. P. Chowdhury, P. Crossley, "Microgrids and Active Distribution Networks", IET Power Electronics Series, 2012.
3. Ali Keyhani Mohammad Marwali and Min Dai, "Integration and Control of Renewable Energy in Electric Power System", 2nd Edition, John Wiley publishing company, 2010

Suggested Reading:

1. Chetan Singh Solanki, "Solar Photovoltaic, Fundamentals, technologies Applications", 3rd Edition, PHI Publishers, 2019.
2. QuingChang Zhong, "Control of Power Inverters in Renewable Energy and Smart Grid Integration", 1St Edition, IEEE-John Wiley and Sons Ltd. Publishers, 2013.
3. Bin Wu, Yongqiang Lang, Navid Zargari, "Power Conversion and Control of Wind Energy Systems", 1st Edition,IEEE- John Wiley and Sons Ltd. Publishers, 2011.
4. Report on "Large Scale Grid Integration of Renewable Energy Sources - Way Forward" Central Electricity

With effect from AY 2023-24

23EEE119

MICROGRID DYNAMICS AND CONTROL

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge on power systems, control system and power electronics

Course Objectives:
This course aims to:

1. Understand the concept of microgrid.
2. Analyze the dynamic modelling and analysis of AC and DC microgrids.
3. Understand the different control schemes for microgrids.

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

1. Understand the basic concept of microgrid.
2. Understand of AC and DC microgrids
3. Analyze the dynamic modelling and analysis of microgrids.
4. Analyze the different hierarchical control schemes for microgrid systems and communication implementation of hierarchical control.
5. Investigate the stability in microgrids and alternate options for stability improvement in microgrids.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	1	3	3	3
CO 2	2	3	3	2
CO 3	3	3	3	3
CO 4	3	2	3	3
CO 5	3	2	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I
Concept of Micro grids: Introduction to the concept of microgrid, overview of the structure and architecture of microgrid with brief control, operational aspects.

UNIT - II
AC-Microgrids: Control Mechanism of the DGs connected in microgrids. Virtual synchronous generator (VSG) and Droop control. Transient frequency response, active power Response, reactive power sharing and voltage regulation

UNIT - III
DC-Microgrids: DC microgrid control mechanism, droop control, issues in achieving active power sharing with impedance droop, remedies achieve active power sharing. Dynamic modelling of individual components in AC and DC microgrids, state space modal analysis and influence of system parameters on microgrid dynamics.

UNIT - IV

Hierarchical control scheme for microgrids: Control Objectives in AC Microgrids, bottleneck with only local control, need of secondary and tertiary control, implementation of hierarchical control with centralized and distributed control schemes for AC and DC microgrids. Advantages and disadvantages of centralized and distributed control schemes.

UNIT - IV

Control of Smart Power Grid System: Load Frequency Control (LFC) in Micro Grid System – Voltage Control in Micro Grid System – Reactive Power Control in Smart Grid. Case Studies and Test beds for the Smart Grids.

Text Books:

1. N. D. Hatziargyriou, "Microgrids Architecture and Control", 1st Edition, IEEE Press Series, John Wiley & Sons Inc, 2013.
2. H. Bevrani, B. François, T. Ise, "Microgrid Dynamics and Control", 1st Edition, John Wiley & Sons, 2017.

Suggested Reading:

1. A. Bidram, V. Nasirian, A. Davoudi, F. L. Lewis, "Cooperative Synchronization in Distributed Microgrid Control", 1st Edition, Springer, 2017.
2. P. Kundur, "Power System Stability and Control", 2nd Edition, McGraw-Hill, Inc., 1994.

With effect from AY 2023-24

23EEE120
EVOLUTIONARY ALGORITHMS APPLICATIONS IN POWER ENGINEERING

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge of basic optimization techniques

Course Objectives:
This course aims to:
1. Provide a broad introduction to the field of conventional optimization problems.
2. Provide a broad introduction to the field of Genetic Algorithms and other fields of Evolutionary Computation and global optimization.
3. Teach students how to apply these methods to solve problems in complex domains.

Course Outcomes:
Upon completion of this course, students will be able to:
1. Familiarize conventional optimization techniques.
2. Analyze the capabilities of bio- Inspired systems and conventional methods for solving optimization problems.
3. Analyze how evolutionary algorithms can be explored and exploited to obtain near global optimal results.
4. Differentiate between evolutionary algorithms.
5. Apply bio- Inspired algorithms Power Engineering applications.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	3	-	3	3
CO 2	3	-	3	3
CO 3	3	-	3	3
CO 4	3	-	3	3
CO 5	3	-	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I
Fundamentals of Soft Computing Techniques: Definition-Classification of optimization problems- unconstrained and Constrained optimization Optimality conditions - Introduction intelligent systems- soft computing techniques- Conventional Computing versus Swarm Computing - Classification of meta-heuristic techniques- Single solution based and population-based algorithms- Properties of Swarm Intelligent Systems.

UNIT - II
Genetic Algorithm (GA): Introduction GAs, Encoding, Fitness, Basic Operators- Selection, Crossover, Mutation, Different types of crossover and mutation operators, Control Parameters Estimation, Niching Methods. Parallel Genetic Algorithms, Genetic Algorithm versus Conventional Optimization Techniques, Detailed working of GA with an example.

UNIT - III

Modified Particle Swarm Optimization: Review of basic Particle Swarm Optimization (PSO), Background of Particle Swarm Optimization, Variations of Particle Swarm Optimization- Discrete PSO, Constriction Factor Approach (CFA), Hybrid PSO (HPSO), Adaptive PSO (APSO), Evolutionary PSO (EPSO), Research Areas and Applications, Detailed working of PSO with an example.

UNIT - IV

Differential Evolution (DE): DE Fundamentals- Initial Population, Mutation, and Recombination Create New Vectors, Selection and the Overall DE, Key Operators for DE- Encoding, Mutation, Crossover, Detailed working of DE with an example.

UNIT - V

Applications Power Systems: Introduction and problem formulation of Economic Dispatch (ED) and Load Frequency Control (LFC). Implementation of ED and LFC with GA, PSO, and DE.

Text Books:

1. Xin-She Yang, "Recent Advances in Swarm Intelligence and Evolutionary Computation", International Edition, Springer International Publishing, Switzerland, 2015.
2. Kalyanmoy Deb, "Multi-Objective Optimization using Evolutionary Algorithms", International Edition, John Wiley & Sons, 2001.
3. Kwang Y. Lee, Mohamed A. EI-Sharkawi, "Modern Heuristic Optimization Techniques, Theory, and applications power systems" IEEE Press Series on Power Engineering, 2008

Suggested Reading:

1. Eric Bonabeau, Marco Dorigo and Guy Theraulaz, "Swarm Intelligence-From natural Artificial Systems", Oxford university Press, 1999
2. James Kennedy and Russel E Eberheart, "Swarm Intelligence", The Morgan Kaufmann Series in Evolutionary Computation, 2001
3. N P Padhy, "Artificial Intelligence and Intelligent Systems", Oxford University Press, 2005
4. I. Aleksandar Lazinica, "Particle Swarm Optimization", Published by In-Tech, 2009

With effect from AY 2024-25

23EEE121

DIGITAL PROTECTION OF POWER SYSTEMS

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge on Power systems, Switchgear and protection

Course Objectives:

This course aims to:

1. Study the architecture and the required mathematical background for the design and development of digital relays.
2. Explore the basic elements in digital relays and understand various algorithms used in digital protection.
3. Understand the application of various algorithms for the digital protection of practical power systems.

Course Outcomes:

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

1. Recognize the need and architecture of digital relays.
2. Comprehend the application of mathematics in power system protection.
3. Describe the importance of every element of digital relay.
4. Distinguish various mathematical algorithms used for the estimation of power system parameters.
5. Explain various algorithms used for the digital protection of power systems.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	2	2	2	3
CO 2	3	2	3	3
CO 3	2	2	3	3
CO 4	3	2	3	3
CO 5	3	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I

Digital Relays: Evolution of digital relays, Advantages, Architecture of digital relays, Performance and operational characteristics of digital protection

Mathematical Background: Finite difference techniques, Forward, backward and central difference interpolation, Numerical differentiation, Curve fitting and smoothing, Fourier analysis, Walsh function analysis.

UNIT - II

Basic Elements of Digital Protection: Signal conditioning: transducers, surge protection, analog filtering, analog multiplexers, Conversion subsystem: the sampling theorem, signal aliasing Error, sample and hold circuits, multiplexers, analog digital conversion, Digital relay subsystem filtering concepts of the digital relay as a UNIT - consisting of hardware and software.

UNIT - III

Sinusoidal-Wave-Based Algorithms: sample, first, second derivative techniques, two - sample and three - sample techniques, Fourier - analysis - based algorithms, walsh - function - based techniques

UNIT - IV

Algorithms based on Least Squares and Differential Equation: Least Squares-based Algorithm: Integral LSQ fitting, Power series LSQ fitting, multi- Variable series LSQ Differential Equation-based Algorithm: Representation of Transmission line, differential equation protection, simultaneous equation techniques,

UNIT - V

Digital Protection: Digital Protection of Transformers: Principles of protection, FIR-filter based algorithms, Least-square curve fitting based algorithms, Fourier-based Algorithms.

Digital Protection Transmission Lines: current-based differential Protection, composite voltage and current- based protection schemes

Text Books:

1. A.T. Johns and S. K. Salman, “Digital Protection of Power Systems”, IEEE Press,1999
2. S.R.Bhide “Digital Power System Protection” PHI Learning Pvt.Ltd.2014

Suggested Reading:

1. Rebizant, Waldemar, Janusz Szafran, and Andrzej Wiszniewski, "Digital signal processing in power system protection and control" Springer, 2011.
2. A.G. Phadke and J. S. Thorp, “Computer Relaying for Power Systems”, Wiley/Research studiesPress, 2009.

NPTEL Courses:

S.No.	NPTEL Course Name	Instructor	Host Institute
1	Digital Protection of Power System	Prof. Bhaveshkumar R. Bhalja	IIT Roorkee

With effect from AY 2024-25

23EEE122

ADVANCED CONTROL TECHNIQUES FOR POWER CONVERTERS

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisites: Students should have knowledge in Power Electronics and Design.

Course Objectives:

This course aims to:

1. Understand modelling of power converters
2. Design PID controllers using different tuning methods.
3. Design different controllers based on resonance.

Course Outcomes:

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

1. Analyze different converter models and their applications.
2. Design PID controllers for power converters and learn different methods of tuning PID controllers.
3. Illustrate resonant controller used for DC-DC boost converter.
4. Design loop shaping method of robust controller.
5. Recognize the concept of sliding mode controller.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	3	1	2	1
CO 2	3	1	2	1
CO 3	3	1	2	1
CO 4	3	1	2	1
CO 5	3	1	2	1

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I

Modeling of Power Converters: Types of Models- Linearized Averaged models- large signal and small signal models- Switched models- Relation between various model types- Control goals in converter operation- Review of classical control methods

UNIT - II

Advanced PID Controller: PID controller-Tuning methods of PID controller- Set point weighting, Integrator Windup- Controller degrees of freedom- Model based Design methods: Direct Synthesis (DS) method, Internal Model Control (IMC) method- Fractional Control System (FOS) -Design of Fractional PID controller- Case Study: PID controller design for DC-DC boost converter.

UNIT - III

Resonant Controller: Necessity of resonant controller- Principle of Proportional Resonant (PR) control- Design methods of PR controller- Example of PR controller design for DC-DC boost converter.

UNIT - IV

Loop-shaping design: Concept of Loop shaping- Robust controller design using the loop shaping methods: H∞ Control, Quantitative feedback theory (QFT)- Case Study: Loop shaping methods design the robust controller for DC-DC converter.

UNIT - V

Sliding Mode Controller (SMC): Nonlinear control preliminaries-Types of Uncertainty-Sliding surface design-Stability of SMC- Equivalent control concept- Integral Sliding Mode Control (ISMC) design- Case study: Application of SMC design the robust controller for DC-DC converter.

Text Books:

1. S. Bacha, I. Munteanu, A.I. Bratcu, "Power Electronic Converters Modeling and Control with Case Studies", 1st Edition, Springer- Verlag London, 2014.
2. L. Wang, S. Chai, D. Yoo, L. Gan, K. Ng, "PID and Predictive control of Electrical Drives and Power Converters using MATLAB/Simulink", 1st Edition, Wiley Press, 2015.
3. C. Olalla, Ramon Leyva, I. Queinnec, "Robust Linear Control of DC-DC Converters: A Practical Approach the Synthesis of Robust Controllers, VDM Verlag- Dr. Muller", 1 st Edition, 2010.
4. A. Mehta, B. Naik, "Sliding Mode controllers for Power Electronic Converters", Springer Nature, 2019

Suggested Reading:

1. SC. Tan, Y-M. Lai, C.K. Tse, "Sliding Mode Control of Switching Power Converters: Techniques and Implementation", 1st Edition, CRC Press, 2012.
2. Hebertt Sira-Ramirez, Ramon Silva-Ortigoza, "Control Design Techniques in Power Electronic Devices", 1st Edition, Springer- Verlag London, 2006.
3. Freede Blaabjerg, "Control of Power Electronic Converters and Systems",1st Edition, Academic Press, 2018.
4. Q- C. Zhong, T. Hornik, "Control of Power Inverters in Renewable Energy and Smart Grid Integration", 1st Edition, Wiley Press, 2013.

NPTEL Courses:

S.No.	NPTEL Course Name	Instructor	Host Institute
1	Advanced Control Systems https://nptel.ac.in/courses/108/103/108103007/	Prof. S. Mahji	IIT, Guwahati
2	Advanced Control System Design for Aerospace Vehicles. https://nptel.ac.in/courses/101/108/101108047/	Dr. Radhakant Padhi	IISc Bangalore

With effect from AY 2024-25

23EEE123

ELECTRIC AND HYBRID VEHICLES

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge of Electrical Machines

Course Objectives:
This course aims to:

1. Understand the concept Electric and Hybrid vehicles, and their advantages and disadvantages.
2. Understand the Performance Characteristics of various types of hybrid electric vehicles, Knowledge of various energy storage system of EV and EHV and energy management.
3. Develop and optimize the design of propulsion motors for EV applications and knowledge of charging technologies.

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

1. Understand the models of describing Electric and hybrid vehicles and their performance.
2. Determine the tractive effort required for EHV and EV with different vehicle parameters and optimization of power train.
3. Design optimization of Electric power train and implementation of charging technology.
4. Analyze the different possible ways of energy storage and battery selection.
5. Illustrate the principle of Hybrid Electric Vehicle, Battery Electric Vehicle and Plug- In EHV and able prepare business plans.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	3	3	2	2
CO 2	3	3	2	2
CO 3	3	3	3	3
CO 4	3	3	3	2
CO 5	3	3	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I

Introduction: Conventional & Electric Vehicles: Basics of Internal Combustion Engine, Four Stroke IC Engine (Petrol & Diesel) principle of operation, and performance, Pressure Volume diagram, Work done (Power Developed) basics, specific Fuel consumption, Mean Effective Pressure, Mechanical Efficiency, Improvement methods for IC Engine Performance, Turbocharging, Air pollution due IC Engine, Global warming and Climate change, Basics of EVs, EV Advantages , Introduction Battery Electric Vehicle (BEV), Components and systems of Electric Vehicle, Performance of EVs , Govt. Policies and guidelines for implementation of electric mobility, Trends and challenges of implementation of electric mobility and start up opportunities.

UNIT - II

Hybrid Electric Vehicles: Introduction Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, Vehicle Mechanics, Vehicle power source characterization, , transmission characteristics using clutch and gear box, gear ratio, Transmission Efficiency, impact

of modern drivetrains on energy supplies and Vehicle grid (V2G) & Grid Vehicle (G2V) fundamentals. Electric Vehicle Modelling– Consideration of Rolling Resistance, Air Drag Resistance, Gradient Resistance, Consideration of Vehicle Mass, – Tractive Effort – Vehicle Acceleration, Selection and Sizing of the propulsion motor, Modelling Electric Vehicle Range, Plug- In electric vehicles,

UNIT - III

Electric and Hybrid Power Trains: Basic concept of hybrid traction, Components, and systems of EHV, introduction various hybrid drive train topologies, concept and modes of operation of Series Hybrid, Parallel Hybrid and Series-Parallel Hybrid Vehicle, Energy management strategies for different modes of operation for EHV, Power flow control in hybrid drive-train topologies, fuel efficiency analysis, Regenerative braking fundamentals, Industrial Qualification, Testing methods and standards, basics of EMI & EMC applicable EHV, Retrofit of Electric Power Train with Conventional vehicle run as EV.

UNIT - IV

Energy Storage and Charging Technology: Introduction Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage, basics of construction and chemical reactions in Lead-acid battery, Lithium based batteries, basics of Metal Air batteries, battery sizing, Super Capacitor based energy storage, Fuel Cell driven Electric Hybrid Vehicle, Hybridization of energy storage batteries with Capacitor based energy storage devices, Different types of EV charging stations for battery charging, Wireless charging technology.

UNIT - V

Design, Analysis, Testing & Qualification of Propulsion Motor: PM Materials (Nd FeB, SmCo, Ferrite and AlNiCo). Properties of NdFeB, SmCo and Ferrite material w.r.t EV/EHV Requirements, Basic concepts of Design, Construction and analysis of water cooled/Air-cooled PM Motor for EV and HEV, Outer rotor PM Motor drive, Permanent Magnet assisted Hybrid Reluctance Motor of EV, Basics of Axial Flux PM Motor , Basic Design and construction Aspects of Induction Motors for EV and HEV, Configuration & control of PM Machines and Induction machines, Use of electromagnetic Software for design optimisation of PM and Induction motor for EV/EHV. Design optimization of PM Motor and Induction Motor for an EV or EHV using standard software.

Text Books:

1. C. Mi, M. A. Masrur, “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. Mehrdad Ehsani, Yimin Gao, Ali Emadi, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals”, CRC Press, 2010.
4. K. T. Chau,“Electric Vehicle, Machines and Drives Design, Analysis And Application” International Research Centre For Electric Vehicles The University Of Hong Kong© 2015 John Wiley & Sons Singapore Pte. Ltd

Suggested Reading:

1. T. Denton, “Electric and Hybrid Vehicles”, Routledge, 2016
2. Hybrid Vehicles and the future of personal transportation, Allen Fuhs, CRC Press, 2011.
3. Vehicle Power Management: Modeling, Control and Optimization, Xi Zhang, Chris Mi, Springer, 2011.
4. National Electric Mobility Mission Plan 2020 Released by DHI, Govt. of India
5. Zero Emission Vehicles (ZEV) Towards a Policy Framework, NITI Aayog
6. IEC and different IS and Eclectic Mobility Standards.
7. Standard Electromagnetic software for analysis
8. James Larminie, “Electric Vehicle Technology Explained”, John Wiley & Sons, 2003

With effect from AY 2024-25

23EEE124

WIDE AREA MONITORING AND CONTROL

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge on power system operation, control and analysis

Course Objectives:
This course aims to:
1. Explain the concept and the importance of Wide-Area Monitoring and Control
2. Demonstrate the architecture of Wide-area monitoring systems.
3. Understand the Wide-area monitoring control and protection philosophies.

Course Outcomes:
Upon completion of this course, students will be able to:
1. Demonstrate the issues and challenges with interconnected power systems.
2. Choose suitable technology for the wide-are monitoring and control.
3. Understand the architecture of Wide-area monitoring system.
4. Assess the operating conditions and stability of the Wide-area power system.
5. Understand the concepts in designing the Wide-area controllers.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	2	3	3	2
CO 2	1	2	3	1
CO 3	2	3	3	2
CO 4	3	3	3	2
CO 5	3	3	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I

Introduction Wide-Area Power Systems: Trends of Interconnected Systems, Stability Problems of Interconnected Systems, WAMS Technology and Its Application in Interconnected Systems, Challenges of Wide Area Dynamic Monitoring and Control, Classification of Disturbance in the Power System, Three Defense Lines in Power System Stability Control, Functions of Defense System, Power System Monitoring and Control with Wide-Area Measurements,

UNIT – II

Wide-Area Technology: Intelligent Electronic Devices (IED), Introduction, Synchronized Phasor Measurement, Phase Measurement UNIT -(PMU), Hierarchy for phasor measurement systems, Communication options for PMUs, Functional requirements of PMUs and PDCs, Supervisory control and data acquisition (SCADA), Components of SCADA systems, SCADA basic functions.

UNIT - III

Wide-Area Monitoring System Architectures: ICT Architecture used in Wide-Area Power System Monitoring and Control, Centralized WAMS architectures, Hierarchical WAMS architectures, Hybrid WAMS architectures, Data collection and management, Issues in data fusion, Intelligent synchrophasor data fusion, Power system data fusion strategies, General framework for data assimilation,

UNIT - IV

Wide-Area Monitoring: Power system health monitoring, Disturbance and anomaly detection, Voltage and reactive power monitoring, Overview of Oscillation Monitoring Using Phasor Measurements, WAMS-Based Inter-area Mode Identification, Oscillation Model Identification Using Phasor Measurements, Small-Signal Stability Assessment of Wide-Area Power System

UNIT - V

Wide-Area Damping Control: Basic Framework and Operating Principle, System Modeling, Coordinated Design of Local PSSs and Wide-Area Damping Controller, Structure of PSS and HVDC, Design Procedure, Robust Coordination of HVDC and FACTS Wide-Area Damping Controllers, Controller Design Formulation, Design Procedure of Wide-Area Robust Coordinated Control

Text Books:

1. Monti, A., Muscas, C., &Ponci, F." Phasor measurement units and wide area monitoring systems", Academic Press, 2016.
2. Bevrani, H., Watanabe, M., & Mitani, Y., "Power system monitoring and control". John Wiley & Sons, 2014.
3. Messina, A. R., "Wide area monitoring of interconnected power systems (No. 10847)". IET, 2015.
4. Phadke, A. G., & Thorp, J. S., "Synchronized phasor measurements and their applications (Vol. 1, p. 81)". New York: Springer, 2008.

Suggested Reading:

1. Rehtanz, C., Li, Y., Cao, Y., & Yang, D., "Interconnected Power Systems: Wide-area Dynamic Monitoring and Control Applications", 2016.
2. Ma, J., "Power system wide-area stability analysis and control". John Wiley & Sons, 2018.

NPTEL Courses:

S.No.	NPTEL Course Name	Instructor	Host Institute
1	Wide Area Monitoring System - I	Dr. Premalata Jena	IIT Roorkee

With effect from AY 2024-25

23EEE125

ENERGY AUDITING AND MANAGEMENT

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisites: None

Course Objectives:
This course aims to:
1. Understand the need for energy auditing.
2. Understand various loads involved based on power consumption for auditing.
3. Know about different audit instruments used in practice.

Course Outcomes:
Upon completion of this course, students will be able to:
1. Acquire the background required for engineers to meet the role of energy managers.
2. Gain the skills and techniques required to implement energy management.
3. Demonstrate energy conservation aspects.
4. Apply the energy conservation techniques Industry and agriculture.
5. Apply Computer aided technologies in Energy Management

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	2	1	1	2
CO 2	3	2	2	2
CO 3	2	1	1	2
CO 4	3	2	2	2
CO 5	3	3	2	3

1 - Slightly; 2 - Moderately; 3 – Substantially

UNIT - I
Energy Auditing: Need for Energy Auditing, Types and objectives, Energy Auditing methodology, Energy Auditing for Buildings, Energy Auditing form for commercial buildings, Case study.

UNIT - II
Energy Audit of Electrical Equipment: Evaluation of energy conservation opportunities and environmental management- Preparation and presentation of energy audit reports, case studies for Induction motors, Transformers, Cables, Lighting, AC systems, Pumps, Capacitor banks and potential energy savings.

UNIT –III
Energy Conservation Aspects: Energy Conservation Needs and Objectives, Energy Conservation in domestic sector, Energy Conservation tips in the kitchen and other domestic House, Energy Conservation measures in office, Energy Conservation opportunities in HVAC system, Demand side Management, Needs and Objectives, Benefits of DSM, DSM design guidelines, DSM implementation Strategy.

UNIT - IV

Energy Conservation in Industrial and Agricultural Sector: Instrumentation: Energy Conservation in industrial Sector, Energy saving potential in Industries –Boiler- Air compressors – Refrigeration System – Heat Exchanger – Electrical Drives – Pumps – Fans and Blowers-, Energy Conservation in Agricultural Sector, Energy Conservation opportunities in Pumps used in Agricultural Sector, Energy Conservation Tips for Agricultural applications.

UNIT - V

Applications of Computer in Energy Management: Role of computers in Energy Management, Simulation as a Design Tool, Energy and Facility Management Software, Industrial Power Management System, Application Terminologies, Power & Energy Management Tools& Equipment

Text Books:

1. Umesh Rathore "Energy Management", 2nd edition, S.K.Kataria& sons
2. Anthony J. Pansini, Kenneth D. Smalling, "Guide Electric Load Management". Pennwell Pub, 1998.
3. Howard E. Jordan, "Energy-Efficient Electric Motors and Their Applications", Plenum Pub Corp, 1994, 2nd Edition

Suggested Reading:

1. Tanuj Kumar Bishat. "SCADA and Energy Management system", 2nd Edition S.K. Kataria & sons.
2. Giovanni Petrecca, Industrial Energy Management: Principles and Applications, The Kluwer international series -207, 1999

With effect from AY 2023-24

23CSO101

BUSINESS ANALYTICS

(Open Elective)

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Course Objectives:

This course aims to:

1. Understanding the basic concepts of business analytics and applications.
2. Study various business analytics methods including predictive, prescriptive and prescriptive analytics.
3. Prepare the students to model business data using various data mining and decision-making methods.

Course Outcomes:

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

1. Identify and describe complex business problems in terms of analytical models.
2. Apply appropriate analytical methods find solutions to business problems that achieve stated objectives.
3. Interpret various metrics, descriptive, predictive and prescriptive measures used in business analytics.
4. Model the business data using various business analytical methods and techniques.
5. Create viable solutions to decision-making problems.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	3	-	-	-
CO 2	3	-	-	2
CO 3	3	-	-	1
CO 4	3	2	2	2
CO 5	3	2	2	2

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I

Introduction Business Analytics: Introduction Business Analytics, need and science of data driven (DD) decision making, Descriptive, predictive, prescriptive analytics and techniques, Big data analytics, Web and Social media analytics, Machine Learning algorithms, frame work for decision making, challenges in DD decision making and future.

UNIT - II

Descriptive Analytics: Introduction, data types and scales, types of measurement scales, population and samples, measures of central tendency, percentile, decile and quadrille, measures of variation, measures of shape-skewness, data visualization.

UNIT - III

Forecasting Techniques: Introduction, time-series data and components, forecasting accuracy, moving average method, single exponential smoothing, Holt's method, Holt-Winte rmodel, Croston's forecasting method, regression model for forecasting, Auregression models, auto-regressive moving process, ARIMA, Theil's coefficient

UNIT - IV

Decision Trees: CHAID, Classification and Regression tree, splitting criteria Ensemble and method and random forest. Clustering: Distance and similarity measures used in clustering, Clustering algorithms, K-Means and Hierarchical algorithms, Prescriptive Analytics-Linear Programming (LP) and LP model building,

UNIT - V

Six Sigma: Introduction, introduction, origin, 3-Sigma Vs Six-Sigma process, cost of poor quality, sigma score,industryapplications,sixsigmameasures,DPMO,yield,sigmascore,DMAICmethodology,SixSigmatoolbox.

Text Books:

1. U Dinesh Kumar, "Data Analytics", 1st Edition, Wiley Publications, 2017
2. Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, "Business analytics Principles, Concepts, and Applications with SAS", Associate Publishers, 2015.

Suggested Readings:

1. S. Christian Albright, Wayne L. Winston, "Business Analytics - Data Analysis and Decision Making", 5th Edition, Cengage, 2015.

NPTEL Courses:

S.No.	NPTEL Course Name	Instructor	Host Institute
1	Advanced Business Decision Support Systems	Prof. Deepu Philip, Prof. Amandeep Singh Oberoi & Prof. Prabal Pratap Singh	IIT Kanpur
2	Business Analytics for Management Decision	Dr. Rudra P. Pradhan	IIT Kharagpur

With effect from AY 2023-24

23MEO101

INDUSTRIAL SAFETY

(Open Elective)

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Course Objectives:

This course aims to:

1. Familiarize causes for industrial accidents and preventive steps be taken.
2. Elucidate fundamental concepts of Maintenance Engineering.
3. Explain about wear and corrosion along with preventive steps be taken.
4. Provide basic concepts and importance of fault tracing.
5. Provide steps involved in carrying out periodic and preventive maintenance of various equipment used in industry.

Course Outcomes:

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

1. Identify the causes for industrial accidents and suggest preventive measures.
2. Identify the basic tools and requirements of different maintenance procedures.
3. Apply different techniques reduce and prevent Wear and corrosion in Industry.
4. Identify different types of faults present in various equipment like machine tools, IC Engines, boilers etc.
5. Apply periodic and preventive maintenance techniques as required for industrial equipment like motors, pumps and air compressors and machine tools etc.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	3	3	3	3
CO 2	3	3	3	3
CO 3	3	1	3	2
CO 4	3	1	3	3
CO 5	3	3	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I

Industrial Safety: 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, Safety color codes, Fire prevention and firefighting, Equipment and methods.

UNIT – II

Fundamentals of Maintenance Engineering: 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: Wear, Types, Causes, Effects, Wear reduction methods, Lubricants, Types and applications, Lubrication methods, General sketch, Working and applications of Screw down grease cup, Pressure grease gun, Splash lubrication, Gravity lubrication, Wick feed lubrication, Side feed lubrication, Ring lubrication, Definition of corrosion, principle and factors affecting the corrosion, Types of corrosion, Corrosion prevention methods.

UNIT–IV

Fault Tracing: 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 any one machine tool, Pump, Air compressor, Internal combustion engine, Boiler, Electrical motors, Types of faults in machine tools and their general causes.

UNIT – V

Periodic and Preventive Maintenance: 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 Machine tools, Pumps, Air compressors, Diesel generating sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, Advantages of preventive maintenance, Repair cycle concept and importance.

Text Books:

1. H. P. Garg, Maintenance Engineering, S. Chand and Company
2. Audels, Pump-hydraulic Compressors, McGraw Hill Publication

Suggested Readings:

1. Higgins & Morrow, Maintenance Engineering Handbook, Da Information Services.
2. Winterkorn, Hans, Foundation Engineering Handbook, Chapman & Hall London

With effect from AY 2023-24

23MEO102

INTRODUCTION OPTIMIZATION TECHNIQUES

(Open Elective)

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Course Objectives:

This course aims to:

1. Come know the formulation of LPP models.
2. Understand the Transportation and Assignment techniques.
3. Come know the procedure of Project Management along with CPM and PERT techniques.
4. Understand the concepts of queuing theory and inventory models.
5. Understand sequencing techniques.

Course Outcomes:

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

1. Formulate a linear programming problem (LPP)
2. Build and solve Transportation Models and Assignment Models.
3. Apply project management techniques like CPM and PERT plan and execute project successfully.
4. Apply queuing and inventory concepts in industrial applications.
5. Apply sequencing models in industries.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	3	1	3	3
CO 2	3	1	3	3
CO 3	1	1	3	3
CO 4	2	1	3	3
CO 5	2	1	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I

Operations Research: Definition, Scope, Models, Linear programming problems (LPP), Formulation, Graphical Method, and Simplex Method

UNIT - II

Transportation Models: Finding an initial feasible solution, North West corner method, Least cost method, Vogel's approximation method, Finding the optimal solution, Special cases in transportation problems, Unbalanced transportation problem, Degeneracy in transportation, Profit maximization in transportation.

UNIT - III

Project Management: Definition, Procedure and objectives of project management, Differences between PERT and CPM, Rules for drawing network diagram, Scheduling the activities, Fulkerson's rule, Earliest and latest times, Determination of ES and EF times in forward path, LS & LF times in backward path, Determination of critical path, Duration of the project, Free float, Independent float and total float.

UNIT - IV

Queuing Theory and Inventory: Kendols notation, Single server models, Inventory control, Deterministic inventory models, Probabilistic inventory control models.

UNIT - V

Sequencing Models: Introduction, Objectives, General assumptions, Processing 'n' jobs through two machines, Processing 'n' jobs through three machines

Text Books:

1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982
3. J.C. Pant, Introduction Optimisation: Operations Research, Jain Brothers, Delhi, 2008

SuggestedReading:

1. Hitler Libermann, Operations Research, McGraw Hill Pub, 2009
2. Harvey M Wagner, Principles of Operations Research, Prentice Hall of India, 2010

With effect from AY 2023-24

23MEO103

COMPOSITE MATERIALS

(Open Elective)

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Course Objectives:

This course aims to:

1. Provide concepts of Composite materials and their constituents.
2. Explain the Classification of the reinforcements and evaluate the behavior of composites.
3. Provide Fabrication methods of metal matrix composites.
4. Explain manufacturing of Polymer matrix composites.
5. Elucidate Failure mechanisms in composite materials.

Course Outcomes:

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

1. Classify and characterize the composite materials.
2. Describe types of reinforcements and their properties.
3. Understand different fabrication methods of metal matrix composites.
4. Understand different fabrication methods of polymer matrix composites.
5. Decide the failure of composite materials.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	3	1	3	3
CO 2	3	1	3	3
CO 3	3	2	3	3
CO 4	3	2	3	3
CO 5	3	1	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I

Introduction: 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: Preparation, Layup, Curing, Properties and applications of glass fibers, Carbon fibers, Kevlar fiber sand boron fibers, Properties and applications of whiskers, Particle reinforcements, Mechanical behavior of composites, Rule of mixtures, Inverse rule of mixtures, Iso strain and iso stress conditions.

UNIT – III

Manufacturing of Metal Matrix Composites: Casting, Solid state diffusion technique, Cladding, Hot iso static 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: Preparation of moulding compounds and prepegs, Hand layup method, Autoclave method, Filament winding method, Compression moulding, Reaction injection moulding, Properties and applications.

UNIT – V

Strength: Lamina failure criteria, Strength ratio, Maximum stress criteria, Maximum strain criteria, Interacting failure criteria, Hygro thermal failure, Laminate first play failure, Insight strength.

Text Books:

1. K.K.Chawla, "Composite Materials- Science and Engineering", 4th edition, Springer Verlag, 2019.
2. WD Callister, Jr., Adapted by R. Balasubramaniam, "Materials Science and Engineering, An introduction".,

Suggested Readings:

1. Deborah D.L. Chung, "Composite Materials Science and Applications" 2nd edition, Springer Verlag, 2010.
2. Sanjay K. Mazumdar, "Composites Manufacturing- materials, product and process engineering", 1st edition, CRC press, 2002.
3. Daniel Gay, "Composite Materials Design and Applications" 3rd edition, CRC press, 2015.

With effect from AY 2023-24

23CEO101

COSTMANAGEMENTOFENGINEERINGPROJECTS

(Common All Branches)

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Course Objectives:

This course aims to:

1. Enable students to understand the concepts of project management, project planning, and scheduling.
2. Provide knowledge of project monitoring and cost management.
3. Understand the concepts of budgetary control and Quantitative techniques for cost management.

Course Outcomes:

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

1. Acquire in-depth knowledge about the concepts of project management and understand the principles of project management.
2. Determine the critical path of a typical project using CPM and PERT techniques.
3. Prepare a work breakdown plan and perform linear scheduling using various methods.
4. Solve problems of resource scheduling and levelling using network diagrams.
5. Learn the concepts of budgetary control and apply quantitative techniques for optimizing project cost.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	2	1	-	-
CO 2	2	1	-	-
CO 3	2	2	-	-
CO 4	2	2	1	1
CO 5	-	1	2	2

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I

Project Management: Introduction to project managements, stake holders, roles, responsibilities and functional relationships. Principles of project management, objectives and project management system. Project team, organization, roles, and responsibilities. Concepts of project planning, monitoring, staffing, scheduling and controlling.

UNIT - II

Project Planning and Scheduling: Introduction for project planning, defining activities and their inter dependency, time and resource estimation. Work breakdown structure. Linear scheduling methods-bar charts, line of balance (lob), their limitations. Principles and definitions of network-based scheduling methods: CPM, PERT. Network representation, network analysis-forward and backward passes.

UNIT - III

Project Monitoring and Cost Analysis: Introduction-cost concepts in decision- making; relevant cost, differential cost, incremental cost and opportunity cost. objectives of a costing system; inventory valuation; creation of a database for operational control; provision of data for decision-making, time cost tradeoff- crashing project schedules, its impact on time on time, cost. Project direct and indirect costs.

UNIT - IV

Resources Management and Costing- Variance Analysis: Planning, enterprise resource planning, resource scheduling and levelling.Total quality management and theory of constraints. Activity-based cost management, bench marking; balanced score card and value-chain analysis.

Standard Costing and Variance Analysis. Pricing strategies: praetor analysis. Target costing, life cycle costing. Costing of service sector. Just- In-time approach, material requirement

UNIT - V

Budgetary Control: Flexible budgets; performance budgets; zero-based budgets. Measurement of divisional profitability pricing decisions including transfer pricing.

Quantitative techniques for cost management: Linear programming, PERT/CPM, transportation assignment problems, simulation, learning curve theory.

Text Books:

1. Charles T Horngren "Cost Accounting A Managerial Emphasis"14 edition, Pearson Education, 2012.
2. Charles T. Horngren and George Foster, "Advanced Management Accounting"6th Revisededition, Prentice-Hall, 1 February 1987.
3. Robert S Kaplan Anthony A. Atkinson, "Management & Cost Accounting",2 edition, Pearson, 18 October 1996.
4. K. K Chitkara, "Construction Project Management: Planning, scheduling and controlling", Tata McGraw-Hill Education. (2004).
5. Kumar NeerajJha "Construction Project Management Theory and Practice", 2 edition,Pearson Education India,2015.

With effect from AY 2023-24

23EEO101

WASTE ENERGY

(Common All Branches)

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge of Energy Conversions.

Course Objectives:

This course aims to:

1. Know the various forms of waste.
2. Extraction of Energy from Waste.
3. Infer the Global and national scenario.

Course Outcomes:

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

1. Understand the concept of waste energy.
2. Explore the various Energy extraction options.
3. Describe the Energy Production methodology.
4. Explicate the Environmental implications.
5. Compare and contrast waste energy productions by case studies.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	1	1	1	1
CO 2	2	1	1	1
CO 3	2	1	1	2
CO 4	1	-	-	1
CO 5	2	2	1	1

1 - Slightly; 2 - Moderately; 3 – Substantially

UNIT - I

Introduction: The Principles of Waste Management and Waste Utilization. Waste Management Hierarchy and 3R Principle of Reduce, Reuse and Recycle. Waste as a Resource and Alternate Energy source.Waste Sources & Characterization Waste production in different sectors such as domestic, industrial, agriculture, postconsumer, waste etc. Classification of waste – agro based, forest residues, domestic waste, industrial waste (hazardous and non-hazardous). Characterization of waste for energy utilization. Waste Selection criteria.

UNIT - II

Energy Extraction Options: Landfill gas, collection and recovery. Refuse Derived Fuel (RDF) – fluff, briquettes, pellets. Alternate Fuel Resource (AFR) – production and use in Cement plants, Thermal power plants and Industrial boilers. Conversion of wastes fuel resources for other useful energy applications Energy from Plastic Wastes: Non-recyclable plastic wastes for energy recovery. Energy Recovery from waste and optimization of its use, benchmarking and standardization. Energy Analysis.

UNIT - III

Energy production Methodologies: Collection, segregation, transportation and storage requirements. Location and Siting of 'Waste Energy' plants. Industry Specific Applications: In-house use: sugar, distillery, pharmaceuticals, Pulp and paper, refinery and petrochemical industry and any other industry. Centralized and Decentralized Energy production, distribution and use. Comparison of Centralized and decentralized systems and its operations.

UNIT - IV

Environmental Implications: Environmental standards for Waste Energy Plant operations and gas clean-up. Savings on non-renewable fuel resources. Carbon Credits: Carbon foot calculations and carbon credits transfer mechanisms.

UNIT - V

Case Studies: Success/failures of waste energy Global Best Practices in Waste energy production distribution and use. Indian Scenario on Waste Energy production distribution and use in India. Success and Failures of Indian Waste Energy plants. Role of the Government in promoting 'Waste Energy.'

Text Books:

1. "Industrial and Urban Waste Management in India", TERI Press.
2. Banwari Lal and Patwardhan, "Wealth from Waste: Trends and Technologies" TERI Press.
3. S.N Mukhopadhyay, "Fundamentals of waste and Environmental Engineering", TERIPress.
4. "Waste-to-Energy in Austria – White Book – Figures, Data Facts", 2nd edition, May 2010.

Suggested Reading:

1. CPCB Guidelines for Co-processing in Cement/Power/Steel Industry
2. Report of the task Force on Waste Energy, Niti Ayog (Formerly Planning Commission) 2014.
3. Municipal Solid Waste Management Manual, CPHEEO, 2016
4. Gazette Notification on Waste Management Rules 2016.

.

With effect from AY 2023-24

23EGA101

ENGLISH FOR RESEARCH PAPER WRITING

(M.E/M. Tech - Common to all Branches)

Instruction	2 L Hours per Week
Duration of SEE	2 Hours
SEE	50 Marks
CIE	-
Credits	0

Prerequisite: Writing express on science and technological concepts with good taste for research and development.

Course Objectives:

This course aims to:

1. Motivate learners for academic writing and thus encourage them for continuous professional updating and up-gradation.
2. Facilitate a practical understanding of the multiple purposes of Writing Research Papers and help them infer the benefits and limitations of research in science and technology.
3. Brainstorm and develop the content, formulating a structure and illustrating the format of writing a research paper.
4. Survey and select a theme/topic for a thorough reading and writing a research paper.
5. Understand how to implement the intricacies of writing and publishing a research paper.

Course Outcomes:

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

1. Improve work performance and efficiency Illustrate the nuances of research paper writing and draw conclusions on professional usefulness.
2. Classify different types of research papers and organize the format and citation of sources.
3. Explore various formats of APA, MLA and IEEE and set up for writing a research paper.
4. Draft paragraphs and write theme-based thesis statements in a scientific manner.
5. Develop an original research paper while acquiring the knowledge of how and where to publish their papers.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	1	2	1	2
CO 2	1	1	1	-
CO 3	2	2	2	1
CO 4	2	2	1	1
CO 5	1	2	1	2

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I

Academic Writing: Meaning &definition of a research paper; Purpose of a research paper - Scope, Benefits, Limitations and outcomes for professional development, An introduction methods and approaches of research.

UNIT –II

Research Paper Format: Title - Abstract - Introduction - Discussion - Findings - Conclusion - Style of Indentation - Font size/Font types - Indexing - Citation of sources.

UNIT –III
Process of Writing a research paper, Writing Draft a Format, develop content, Adapting, Reviewing, Paraphrasing& Plagiarism Checks.

UNIT - IV
Choosing a topic - Thesis Statement - Outline - Organizing notes - Language of Research - Word order, Paragraphs - Writing first draft-Revising/Editing - The final draft and proof reading. Understanding APA, MLA, IEEE formats.

UNIT - V
Research Paper Publication Reputed Journals –Paid, Free and peer reviewed journals, National/International - ISSN No, No. of volumes, Scopus Index/UGC Journals. Getting Papers Published.

Text Books:

1. Kothari, C. R. and Gaurav, Garg, "Research Methodology Methods and Techniques", 4thEdition, New Age International Publishers, New Delhi, 2019.
2. Ellison, Carroll. "Writing Research Papers", McGraw Hill's Concise Guide, 2010.
3. Lipson, Charles. "Cite Right: A Quick Guide to Citation Styles-- MLA, APA, Chicago, the Sciences, Professions, and More", 2nd Edition, University of Chicago Press. Chicago, 2018.

Suggested Reading:

1. Day, Robert A. "How to Write and Publish a Scientific Paper", Cambridge University Press, 2006
2. Girden, E. R. "MLA Handbook for Writers of Research Papers", 7th Edition, East West Press Pvt. Ltd, New Delhi, 2009
3. Bailey, Stephen. "Academic Writing: A Handbook for International Students", Routledge, 2018

NPTEL Courses:

S.No.	NPTEL Course Name	Instructor	Host Institute
1	Introduction to Research (Research Methodology)	Dr. Prathap Haridoss, Dr. G. Phanikumar, Dr. Arun K.Tangirala, Prof. M.S. Ananth, Prof. C. Balaji, Dr. Abhijit P. Deshpande, Prof. Edamana Prasad	IIT Madras
Other Writing Tools:			
1	https://owl.purdue.edu/owl_exercises/index.html - The Owl writing lab		
2	https://www.turnitin.com/login_page.asp?lang=en_us – Turnitin software		

With effect from AY 2023-24

23EGA102

INDIAN CONSTITUTION AND FUNDAMENTAL PRINCIPLES

(M.E/M. Tech - Common to all Branches)

Instruction	2 L Hours per Week
Duration of SEE	2 Hours
SEE	50 Marks
CIE	-
Credits	0

Prerequisite: Knowledge of the basics of the Constitution and the Government.

Course Objectives:

This course aims to:

1. Know the history of Indian Constitution and its role in the Indian democracy.
2. Address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement. civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.
3. Have knowledge of the various Organs of Governance and Local Administration.

Course Outcomes:

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

1. Understand the making of the Indian Constitution and its features.
2. Understand the Rights of equality, the Right of freedom and the Right constitutional remedies.
3. Have an insight into various Organs of Governance - composition and functions.
4. Understand powers and functions of Municipalities, Panchayats and Co-operative Societies.
5. Understand Electoral Process, special provisions.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	2	1	-	1
CO 2	2	1	-	1
CO 3	2	1	-	1
CO 4	2	1	-	1
CO 5	2	1	-	1

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I

History of making of the Indian constitutions: History, Drafting Committee (Composition & Working). **Philosophy of the Indian Constitution:** Preamble, Salient Features.

UNIT - II

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

UNIT - III

Organs of Governance: Parliament: Composition, Qualifications, Powers and Functions

Union executives: President, Governor, Council of Ministers, Judiciary, appointment and transfer of judges, qualifications, powers and functions

UNIT - IV

Local Administration: District's Administration head: Role and importance. Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation. Panchayati Raj: Introduction, PRI Zilla Panchayat, Elected Officials and their roles, CEO Zilla Panchayat: positions and role.

Block level: Organizational Hierarchy(Different departments) Village level: role of elected and appointed officials. Importance of grass root democracy.

UNIT - V

Election commission: Election Commission: Role and functioning, Chief Election Commissioner and Election Commissioners, State Election Commission: Role and functioning. Institute and Bodies for the welfare of SC/ST/OBC and women.

Text Books:

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

SuggestedReading:

1. Bhargava, Rajeev. (ed), "Politics and Ethics of the Indian Constitution", OUP, 2008.
2. NCERT, Indian Constitution at Work, 1st Edition, Government of India, New Delhi 2006, reprinted in 2022.
3. Ravindra Sastry, V. (ed.), Indian Government & Politics, 2nd edition, Telugu Academy, 2018.

With effect from AY 2023-24

23EGA103

STRESS MANAGEMENT BY YOGA

(M.E/M. Tech - Common to all Branches)

Instruction	2 L Hours per Week
Duration of SEE	2 Hours
SEE	50 Marks
CIE	-
Credits	0

Prerequisite: Knowledge of Yoga Practices.

Course Objectives:

This course aims to:

1. Create awareness about different types of stress and the role of yoga in the management of stress.
2. Promote positive health and overall wellbeing (Physical, mental, emotional, social and spiritual).
3. Prevent stress related health problems by yoga practice.

Course Outcomes:

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

1. Understand yoga and its benefits.
2. Enhance Physical strength and flexibility.
3. Learn to relax and focus.
4. Relieve physical and mental tension through asanas.
5. Improve work performance and efficiency.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	2	1	-	1
CO 2	2	1	-	1
CO 3	2	1	-	1
CO 4	2	1	-	1
CO 5	2	1	-	1

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT –I

Meaning and definition of Yoga - Historical perspective of Yoga - Principles of Astanga Yoga by Patanjali.

UNIT - II

Meaning and definition of Stress - Types of stress - Eustress and Distress. Anticipatory Anxiety and Intense Anxiety and depression. Meaning of Management- Stress Management.

UNIT - III

Concept of Stress according to Yoga - Stress assessment methods - Role of Asana, Pranayama and Meditation in the management of stress.

UNIT - IV

Asanas- (5 Asanas in each posture) - Warm up - Standing Asanas - Sitting Asanas - Prone Asanas - Supine asanas - Surya Namaskar

UNIT - V

Pranayama- Anulom and Vilom Pranayama - Nadishudhi Pranayama - Kapalabhati Pranayama - Bhramari Pranayama - Nadanusandhana Pranayama.

Meditation techniques: Om Meditation - Cyclic meditation: Instant Relaxation technique (QRT), Quick Relaxation Technique (QRT), Deep Relaxation Technique (DRT)

Suggested Reading:

1. Janardhan Swami "Yogic Asanas for Group Training - Part- I": YogabhyasiMandal,Nagpur.
2. Swami Vivekananda, AdvaitaAshrama"Rajayoga or Conquering the Internal Nature" Publication Department,Kolkata.
3. Nagendra H.R and Nagaratna R, "Yoga Perspective in Stress Management", Bangalore, Swami Vivekananda YogaPrakashan

NPTEL Courses:

S.No.	NPTEL Course Name	Instructor	Host Institute
1	Indian Philosophy	Prof. Satya Sundar Sethy	IIT Madras

With effect from AY 2023-24

23EGA104

PERSONALITY DEVELOPMENT THROUGH LIFE'S ENLIGHTENMENT SKILLS

(M.E/M. Tech - Common to all Branches)

Instruction	2 L Hours per Week
Duration of SEE	2 Hours
SEE	50 Marks
CIE	-
Credits	0

Prerequisite: Awareness on Personality Development.

Course Objectives:

This course aims to:

1. Learn to achieve the highest goal happily.
2. Become a person with a stable mind, pleasing personality and determination.
3. Awake wisdom among themselves.

Course Outcomes

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

1. Develop their personality and achieve their highest goal in life.
2. Lead the nation and mankind to peace and prosperity.
3. Practice emotional self-regulation.
4. Develop a positive approach to work and duties.
5. Develop a versatile personality.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	1	1	-	1
CO 2	1	1	-	1
CO 3	1	1	-	1
CO 4	1	1	-	1
CO 5	1	1	-	1

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I

Neetisatakam – Holistic development of personality - Verses 19, 20, 21, 22 (Wisdom) - Verses 29, 31, 32 (Pride and Heroism) - Verses 26,28,63,65 (Virtue)

UNIT - II

Neetisatakam – Holistic development of personality (cont'd) - Verses 52, 53, 59 (dont's) - Verses 71,73,75& 78 (do's) - Approach to day to day works and duties.

UNIT - III

Introduction to Bhagavadgeetha for Personality Development – Shrimad Bhagawad Geeta: Chapter 2–Verses 41, 47, 48 - Chapter 3 – Verses 13,21,27,35 - Chapter 6 – Verses 5,13,17,23,35 - Chapter 18 –Verses 45, 46, 48 Chapter – 6: Verses 5, 13, 17, 23, 35; Chapter – 18: Verses 45, 46, 48

UNIT - IV

Statements of basic knowledge – Shrimad Bhagawad Geeta: Chapter 2- Verses 56, 62,68 - Chapter 12 – Verses 13, 14, 15, 16, 17, 18 - Personality of Role model from ShrimadBhagawatGeeta.

UNIT - V

Role of Bahgavadgeeta in the present scenario - Chapter 2 – Verses 17 - Chapter 3 – Verses 36, 37, 42 - Chapter 4 – Verses 18, 38, 39 - Chapter 18 – Verses 37, 38, 63.

Text Books:

1. Gopinath, P., "Bhartrihari's Three Satakam (Niti-sringar- Vairagya)", Rashtriya Sanskrit Sansthanam, New Delhi, 2018.
2. Swarupananda, Swami, "Srimad Bhagavad Geeta", Advaita Ashram (Publication Dept), Kolkata, 2017.

NPTEL Courses:

S.No.	NPTEL Course Name	Instructor	Host Institute
1	Enhancing Soft Skills and Personality	Prof. T.Ravichandran	IIT Kanpur

With effect from AY 2023-24

23ECA101

VALUE EDUCATION

(Audit Course)

Instruction	2 L Hours per Week
Duration of SEE	2 Hours
SEE	50 Marks
CIE	-
Credits	0

Prerequisite: Knowledge about universal human values.

Course Objectives:

This course aims to:

1. Understand Value Education, self-development and National development.
2. Imbibe good human values and Morals in students.
3. Let the student know about the importance of character.

Course outcomes:

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

1. Summarize classification of values and values for self-development.
2. Identify the importance of values in personal and professional life.
3. Apply the importance of social values for better career and relationships.
4. Compile the values from holy books for personal and social responsibility.
5. Discuss concept of soul and reincarnation, values Dharma, Karma and Guna.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	1	1	1	3
CO 2	1	1	1	3
CO 3	1	1	1	3
CO 4	1	1	1	3
CO 5	1	1	1	3

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I

Human Values, Ethics and Morals: Concept of Values, Human Values, Indian concept of humanism, Values for self-development, social values, Individual attitudes, Work ethics, Moral and non- moral behavior, Standards and Principles based on religion, Culture and Tradition.

UNIT - II

Value Cultivation, and Self-Management: Need for and Importance of cultivation of values such as Sense-of Duty, Devotion work, Self-reliance, Confidence, Concentration, Integrity & discipline, and Truthfulness.

UNIT - III

Spiritual Outlook and Social Values: Personality and Behavior Development, Scientific attitude and Spiritual (soul) outlook, Cultivation of Social Values Such as Positive Thinking, Punctuality, Love & Kindness, avoiding fault finding in others, Reduction of anger, Forgiveness, Dignity of labor, True friendship, Universal brotherhood and religious tolerance., Happiness Vs Suffering, Love for truth, Aware of self-destructive habits, Appreciation and co-operation.

UNIT - IV

Values in Holy Books: Self-management, good health and internal & external cleanliness**,** Holy books versus Blind faith, Character and Competence, Equality, Nonviolence, Humility, Role of Women.

UNIT - V

All religions and same message: Mind your mind, Self-control**,** Concept of soul, Science of Reincarnation, Character and Conduct, Concept of Dharma, Cause and Effect based Karma Theory, The qualities of Devine and Devilish;,Satwic, Rajasic and Tamasic gunas.

Text Book:

1. Chakroborty, S.K. "Values & Ethics for organizations Theory and practice", Oxford University Press, New Delhi, 1998.

Suggested Reading:

1. Jaya DayalGoyandaka, "Srimad Bhagavad Gita", with Sanskrit Text, Word meaning and Prose meaning, Gita Press, Gorakhpur, 2017.

With effect from AY 2023-24

23CEA101

DISASTER MITIGATION AND MANAGEMENT

(Audit Course)

Instruction	2 L Hours per Week
Duration of SEE	2 Hours
SEE	50 Marks
CIE	-
Credits	-

Prerequisite: None.

Course Objectives:

This course aims to:

1. Equip the students with the basic knowledge of hazards, disasters, risks and vulnerabilities including natural, climatic and human induced factors and associated impacts.
2. Impart knowledge in students about the nature, causes, consequences and mitigation measures of the various natural disasters.
3. Enable the students to understand risks, vulnerabilities and human errors associated with human induced disasters.
4. Enable the students to understand and assimilate the impacts of any disaster on the affected area depending on its position/ location, environmental conditions, demographic, etc.
5. Equip the students with the knowledge of the chronological phases in a disaster management cycle and to create awareness about the disaster management framework and legislations in the context of national and global conventions.

Course outcomes:

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

1. Analyse and critically examine existing programs in disaster management regarding vulnerability, risk and capacity at different levels.
2. Understand and choose the appropriate activities and tools and set up priorities to build a coherent and adapted disaster management plan.
3. Understand various mechanisms and consequences of human induced disasters for the participatory role of engineers in disaster management.
4. Understand the impact on various elements affected by the disaster and suggest and apply appropriate measures for the same.
5. Develop an awareness of the chronological phases of disaster preparedness, response and relief operations for formulating effective disaster management plans and ability understand various participatory approaches/strategies and their application in disaster management.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	2	2	-	1
CO 2	1	2	-	1
CO 3	1	1	-	1
CO 4	1	2	-	1
CO 5	1	2	-	1

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I

Introduction: Basic definitions- Hazard, Disaster, Vulnerability, Risk, Resilience, Mitigation, Management; classification of types of disaster- Natural and manmade; International Decade for natural disaster reduction (IDNDR); International strategy for disaster reduction (ISDR), National disaster management authority (NDMA).

.

UNIT - II

Natural Disasters: Hydro meteorological disasters: Causes, Early warning systems- monitoring and management, structural and non-structural measures for floods, drought and Tropical cyclones; Geographical based disasters: Tsunami generation, causes, zoning, Early warning systems- monitoring and management, structural and non-structural mitigation measures for earthquakes, tsunami, landslides, avalanches and forest fires. Case studies related various hydro meteorological and geographical based disasters.

UNIT - III

Human induced hazards: Chemical disaster- Causes, impacts and mitigation measures for chemical accidents, Risks and control measures in a chemical industry, chemical disaster management; Case studies related various chemical industrial hazards eg: Bhopal gas tragedy; Management of chemical terrorism disasters and biological disasters; Radiological Emergencies and case studies; Case studies related major power break downs, fire accidents, traffic accidents, oil spills and stampedes, disasters due double cellar construction in multi storied buildings.

UNIT - IV

Disaster Impacts: Disaster impacts- environmental, physical, social, ecological, economical, political, etc.; health, psycho-social issues; demographic aspects- gender, age, special needs; hazard locations; global and national disaster trends; climate change and urban disasters.

UNIT - V

Concept of Disaster Management: Disaster management cycle – its phases; prevention, mitigation, preparedness, relief and recovery; risk analysis, vulnerability and capacity assessment; Post-disaster environmental response water, sanitation, food safety, waste management, disease control; Roles and responsibilities of government, community, local institutions, NGOs and other stakeholders; Policies and legislation for disaster risk reduction, DRR programmes in India and the activities of National Disaster Management Authority

Text Book:

1. Pradeep Sahni," Disaster Risk Reduction in South Asia", Prentice Hall, 2003.
2. B. K. Singh," Handbook of Disaster Management: techniques & Guidelines", Rajat Publication, 2008.
3. Ministry of Home Affairs". Government of India, "National disaster management plan, Part I and II",
4. K. K. Ghosh," Disaster Management", APH Publishing Corporation, 2006.

Suggested Reading:

1. http://www.indiaenvironmentportal.org.in/files/file/ disaster_management_india1.pdf
2. http://www.ndmindia.nic.in/ (National Disaster management in India, Ministry of Home Affairs)
3. Hazards, Disasters and your community: A booklet for students and the community, Ministry of home affairs.

With effect from AY 2023-24

23ADA101

PEDAGOGY STUDIES

(Audit Course – 1&2)

Instruction	2 L Hours per Week
Duration of SEE	2 Hours
SEE	50 Marks
CIE	-
Credits	-

Prerequisite: None.

Course Objectives:

This course aims to:

1. Present the basic concepts of design and policies of pedagogy studies.
2. Provide understanding of the abilities and dispositions with regard teaching techniques, curriculum design and assessment practices.
3. Familiarize various theories of learning and their connection teaching practice.
4. Create awareness about the practices followed by DFID, other agencies and other researchers.
5. Provide understanding of critical evidence gaps that guide professional development.

Course outcomes:

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

1. Illustrate the pedagogical practices followed by teachers in developing countries both in formal and informal classrooms.
2. Examine the effectiveness of pedagogical practices.
3. Understand the concept, characteristics and types of educational research and perspectives of research.
4. Describe the role of classroom practices, curriculum and barriers learning.
5. Understand Research gaps and learn the future directions.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	1	1	1	--
CO 2	1	1	1	1
CO 3	2	2	2	1
CO 4	1	1	1	1
CO 5	2	2	2	2

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT- I

Introduction and Methodology: 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: Pedagogical practices followed by teachers in formal and informal classrooms in developing countries - Curriculum, Teacher education.

UNIT- III

Evidence on the Effectiveness of Pedagogical Practices: Methodology for the in depth stage: quality assessment of included studies - How can teacher education (curriculum and Practicum) and the school curriculum and guidance material 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: alignment with classroom practices and follow up support - Support from the head teacher and the community – Curriculum and assessment - Barriers learning: Limited resources and large class sizes.

UNIT- V

Research Gaps and Future Directions: Research design – Contexts – Pedagogy - Teacher education - Curriculum and assessment – Dissemination and research impact.

Text Book:

1. Ackers J, Hardman F, "Classroom Interaction in Kenyan Primary Schools, Compare", 31 (2): 245 – 261, 2001.
2. Agarwal M, "Curricular Reform in Schools: The importance of evaluation", Journal of Curriculum Studies, 36 (3): 361 – 379, 2004.

With effect from AY 2023-24

23 EE A101

SANSKRIT FOR TECHNICAL KNOWLEDGE

Instruction	2 Hours per Week
Duration of SEE	2 Hours
SEE	50 Marks
CIE	-
Credits	-

Prerequisite: None

Course Objectives:
This course aims to:

1. Get a working knowledge in illustrious Sanskrit, the scientific language in the world.
2. Make the novice Learn the Sanskrit develop the logic in mathematics, science & other subjects.
3. Explore the huge knowledge from ancient literature.

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

1. Develop passion towards Sanskrit language.
2. Decipher the latent engineering principles from Sanskrit literature.
3. Correlates the technological concepts with ancient Sanskrit history.
4. Develop knowledge for technological progress.
5. Explore the avenue for research in engineering with the aid of Sanskrit.

CO-PO Articulation Matrix

PO / CO	PO 1	PO 2	PO 3	PO 4
CO 1	-	1	1	1
CO 2	2	1	1	1
CO 3	2	1	1	1
CO 4	2	1	1	1
CO 5	2	1	1	1

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I

Introduction Sanskrit language: Sanskrit Alphabets- Vowels-consonants- significance of Amarakosa-parts of speech - Morphology - creation of new words - significance of synonyms-sandhi-samasa-sutras-active and passive voice-Past/Present/Future Tense - syntax - Simple Sentences (elementary treatment only)

UNIT - II

Role of Sanskrit in Basic sciences: Brahmagupthas lemmas (second degree indeterminate equations), sum of squares of n-terms of AP- sulba_sutram or baudhayana theorem (origination of pythogorous theorem)- Value of pie-Madhavas sine and cosine theory (origination of Taylors series). The measurement system-time-mass-length-temp, Matter elasticity-optics-speed of light (origination of michealson and morley theory).

UNIT - III

Role of Sanskrit in Engineering- I (Civil, Mechanical, Electrical and Electronics Engineering): Building construction-soil testing-mortar-town planning-Machine definition-crucible-furnace-air blower - Generation of electricity in a cell- magnetism - Solar system - Sun: The source of energy, the earth-Pingala chandasutram (origination of digital logic system)

UNIT - IV

Role of Sanskrit in Engineering- II (Computer Science Engineering & Information Technology): Computer languages and the Sanskrit languages-computer command words and the vedic command words-analogy of pramana in memamsa with operators in computer language-sanskrit analogy of physical sequence and logical sequence, programming.

UNIT - V

Role of Sanskrit in Engineering- III (Biotechnology and Chemical Engineering): Classification of plants-plants, the living-plants have senses-classification of living creatures- Chemical laboratory location and layout-equipment-distillation vessel-kosthiyanthram

Text Books:

1. M Krishnamachariar, "History of Classical Sanskrit Literature", TTD Press, 1937.
2. Kpail Kapoor, Language, "Linguistics and Literature: The Indian Perspective", ISBN-10: 8171880649, 1994.
3. "Pride of India", Samskrita Bharti Publisher, ISBN: 81-87276-27-4, 2007
4. Shri Rama Verma, "Vedas the source of ultimate science", Nag publishers, ISBN: 81-7081-618-1, 2005

Suggested Reading:

1. "The Wonder that is Sanskrit", AuroPublications, ISBN: 978-8170601821, 2017.
2. "Science in Sanskrit", Samskrita Bharti Publisher, ISBN-13: 978-8187276333, 2007
3. "A Treasury of Indian Wisdom: An Anthology of Spiritual Learn", ISBN: 978-0143426158, 2016.