SYLLABUS

(With effect from 2024 -25)

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(±ÉÊPÀëtÂPÀ ªÀµÀð 2024-25)

Bachelor Degree

In

Electrical & Electronics Engineering

VII & VIII Semester

Out Come Based Education

With

Choice Based Credit System

[National Education Policy Scheme]

P.E.S. College of Engineering, Mandya - 571 401, Karnataka

[An Autonomous Institution affiliated to VTU, Belagavi,
Grant – in – Aid Institution (Government of Karnataka),
Accredited by NBA (All UG Programs), NAAC and Approved by AICTE, New Delhi]

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

Profile

Department of Electrical & Electronics Engineering Programme has been accredited by NBA for 6 Academic years (2017-18 to 2022-23)

The Department of Electrical and Electronics Engineering was established right from the inception of the institute in the year 1962. The various programs offered by the Department are B.E., M.Sc., (Engg.) by research and research leading Ph.D affiliated to Visvesvaraya Technological University (VTU), Belagavi. Also, Department is affiliated for Ph.D program with University of Mysore, Mysore . More than 100 research papers have been published by the Department faculty members in various International & National journals and conferences.

The Department emphasizes towards imparting quality education, rigorous teaching-learning, hands-on expertise and helping students to shape their all-round personality. The Department with its strong pool of faculty, well-developed laboratories, latest software and hardware facilities, contributes to develop life-long learning skills to its students and producing worthy researchers by offering doctoral research program.

The academic programs are designed and updated keeping in view the constantly changing industrial needs, skills and challenges emerging out of new research. The academic programs are well received by the industry and academia. The department has always exerted the best of its effort to meet the objectives of achieving technical excellence in the areas of Electrical and Electronics Engineering such as High Voltage Engineering, Power Electronics & Drives, Control Systems, Power Systems, Energy Systems, Analog and Digital Electronics, Signal Processing, PLC & SCADA and Microcontrollers

The Department regularly organizes industrial visits, Technical lectures by experts from industries and institutes in contemporary areas to bridge the gap between syllabi and current developments.

VISION

The department of E & E would endeavor to create a pool of Engineers who would be technically competent, ethically strong also fulfill their obligation in terms of social responsibility.

MISSION

- Adopt the best pedagogical methods and provide the best facility, infrastructure and an ambience conducive to imbibe technical knowledge and practicing ethics.
- Group and individual exercises to inculcate habit of analytical and strategic thinking to help the students to develop creative thinking and instil team skills.
- MOUs and Sponsored projects with industry and R & D organizations for Collaborative learning
- Enabling and encouraging students for continuing Education and moulding them for life-long learning process

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO1: Excel in professional career and/or higher education by acquiring knowledge in mathematical, computing and Electrical & Electronics engineering principles

PEO2: Analyze real life problems and Design Electrical & Electronics Engineering system with appropriate solutions that are technically sound, economically feasible and socially acceptable

PEO3: Exhibit professionalism, ethical attitude, communications skills, team work in their profession and adapt to current trends by engaging in lifelong learning.

PROGRAMME OUTCOMES (POs)

PO-1: Graduates will apply the knowledge of mathematics, Physics, chemistry and allied engineering subjects to solve problems in Electrical and Electronics Engineering.

PO-2: Graduates will Identify, formulate and solve Electrical and Electronics Engineering problem.

PO-3: Graduates will design Electrical and Electronics systems meeting the given specifications for different problems taking safety and precautions into consideration.

PO-4: Graduates will design, conduct experiments, analyze and interpret data

PO-5: Graduates will use modern software tools to model and analyze problems, keeping in view their limitations.

PO-6: Graduates will understand the impact of local and global issues / happenings on Electrical Engineers.

PO-7: Graduates will provide sustainable solutions for problems related to Electrical and Electronics Engineering and also will understand their impact on environment.

PO-8: Graduates will have knowledge of professional ethics and code of conduct as applied to Electrical Engineers.

PO-9: Graduates will work effectively as an individual and as a member or leader in diverse teams and in multi-disciplinary settings.

PO-10: Graduates will communicate effectively in both verbal and written form.

PO-11: Graduates will plan, execute and complete projects

PO-12: Graduates will have the ability for self- education and lifelong learning

PROGRAMME SPECIFIC OUTCOMES (PSOs)

PSO1: To understand the concept in Electrical and Electronics Engineering and apply them to develop modules analyze assess the performance of various power system equipment, generation, transmission, utilization and protection mechanisms.

PSO2: Design, develop, analyze and test electrical and electronics system: Deploy control strategies for electrical dives, power system networks, power electronics, high voltage and other related applications.

VII Semester B.E Electrical & Electronics Engineering

Bachelor of Engineering (VII –Semester)										
Sl. No.	Course Code	Course Title	Teaching Department	Hrs / Week			Credits	Examination Marks		
				L	T	P		CIE	SEE	Total
1	P21EE701	Industrial Drives & Applications	E&EE	3	-	-	3	50	50	100
2	P21EE702X	**Professional Elective Course – IV**	E&EE	3	-	-	3	50	50	100
3	P21EE703X	**Professional Elective Course – V**	E&EE	3	-	-	3	50	50	100
4	P21EE704	HV (Integrated)	E&EE	3	-	2	4	50	50	100
5	P21EE705	Research Methodology, Report Writing and IPR	E&EE	3	-	-	3	50	50	100
6.	P21EE706	Project Work Phase – I	E&EE	-	-	-	4	100	-	100
Total							**20**			

Professional Elective Course – IV (P21EE702X)	
Course Code	**Course Title**
P21EE7021	Testing & Commissioning of Electrical Equipment
P21EE7022	Modern Control Theory
P21EE7023	Power system operation and control
P21EE7024	Electric Vehicles

Professional Elective Course – V (P21EE703X)	
Course Code	**Course Title**
P21EE7031	Energy auditing and DSM
P21EE7032	Smart grid Technology
P21EE7033	HVDC Power Transmission
P21EE7034	Artificial Neural Network and Artificial Intelligence

VIII Semester B.E Electrical & Electronics Engineering

Bachelor of Engineering (VIII –Semester)										
Sl. No.	Course Code	Course Title	Teaching Department	Hrs / Week			Credits	Examination Marks		
				L	T	P		CIE	SEE	Total
1	P21EE801	Self-Study Course (MOOC's)	E&EE	-	-	-	2	100	-	100
2	P21INT802	Research / Industry Internship – III	E&EE	-	-	-	6	-	100	100
3	P21EE803	Project Work Phase – II	E&EE	-	-	-	8	100	100	100
Total							**16**			

***Allot Tutorial as per the course requirement subjected to the credits allotted.**

Industrial Drives & Applications

[As per Choice Based Credit System (CBCS) & OBE Scheme]

SEMESTER – VII

Course Code:	**P21EE701**	**Credits:**	**03**
Teaching Hours/Week (L:T:P):	**3:0:0**	**CIE Marks:**	**50**
Total Number of Teaching Hours:	**40**	**SEE Marks:**	**50**

Course Learning Objectives: This course will enable the students to:

- Understand the fundamental concepts of electric drives, including their advantages, components, and selection criteria, as well as the current status of DC and AC drives in the industry.
- Analyze the dynamics of electrical drives by mastering fundamental torque equations, speed-torque conventions, and multi-quadrant operation, and learn how to calculate time and energy loss in transient operations.
- Gain proficiency in converter-fed and DC drives, including rectifier-controlled DC drives (single-phase and three-phase), Ward Leonard drives, and dual converter-fed drives, and understand their operational modes under different current conditions.

UNIT – I	**Introduction**	**8 Hours**

Introduction: Electric Drives, Advantages of Electrical Drives, Parts of Electrical Drives, Choice of Electrical Drives, Status of DC &AC Drives.

Dynamics of Electrical Drives: Fundamental Torque Equations, Speed Torque Conventions and Multi-quadrant Operation. Equivalent Values of Drive Parameters, Components of Load Torques, Nature and Classification of Load Torques, Calculation of Time and Energy Loss in Transient Operations, Steady State Stability

Self-study component:	Load Equalization.

UNIT – II	**Converter-fed DC Drives**	**8 Hours**

Rectifier controlled DC Drives: single phase Half & Fully controlled rectifier fed dc drives, (separately &series dc motors) under continuous and discontinuous current mode, Ward Leonard drives. Three phase half controlled rectifier control of dc separately exited motor, Three phase fully controlled rectifier control of dc separately exited motor converter fed dc drives, dual converter fed drives

Self-study component:	Controlled rectifier-fed dc drives

UNIT – III	**Chopper-fedDrive and DC Motor Braking**	**8 Hours**

Chopper controlled DC drives: Chopper controlled DC drives – Chopper Control Of Separately exited DC motor (motoring and braking operation, multi-quadrant operation of chopper) Chopper control of series motor (motoring and braking operation).

Concept of DC motor braking: Methods of braking – regenerative & dynamic braking

Self-study component:	Plugging

UNIT – IV	AC Drives	8 Hours

AC Drives: Introduction to three phase Induction Motor drives, Analysis and Performance, Speed and Torque control methods: Stator voltage control, rotor voltage control, Stator frequency control, Voltage and frequency control, VSI fed IM drive, Induction motor drives, CSI fed IM drive,Static Kramer drive, Static Scherbius drive and braking of IM.

Self-study component:	Eddy current drives

UNIT – V	Synchronous motor Drives	8 Hours

Synchronous motor Drives: Introduction, Variable frequency control, Self controlled synchronous motor employing load commutated thyristor inverter.
Industrial drives: Rolling mill drives, Textile mill drives, Cement mill drives, Paper mill drives.

Self-study component:	Starting large synchronous machines.

Course Outcomes: On completion of this course, students are able to

COs	**Course Outcomes** with ***Action verbs*** for the Course topics	**Bloom's Taxonomy Level**	**Level Indicator**
CO1	Explain the basic concepts of AC & DC Drives and its applications.	Understand and Remember	L1, L2
CO2	Apply the knowledge of power electronics to solve the problems related to AC & DC Drives.	Apply	L3
CO3	Analyze the performance of AC & DC drives	Analyze	L4

Text Book(s):

1. "Electric drives" by G.K Dubey, Narosa publishing house, second Edition 2011.
2. "A first course in Electric Drives", S K Pillai, Wiley Eastern ltd, 1990

Reference Book(s):

1. "Thyristor control of electric Drives",V.Subramanyam, Tata McGraw Hill, second Edition 2007.
2. "Power Semiconductor Drives", S.Sivanagaraju, PHI publications,1st Edition,2008
3. "Power electronics", M.H Rashid, PHI, third edition 2012.
4. Power Electronics: Principles and Applications, Joseph Vithayathil,Publisher(s):McGraw-Hill College,1995

Course Outcomes		Program Outcomes													
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	Explain the basic concepts of ac & dc drives and its applications.	3	-	-	-	-	-	-	-	-	-	-	2	-	2
2	Apply the knowledge of power electronics to solve the problems related to AC & DC Drives.	3	-	-	-	-	-	-	-	-	-	-	-	-	2
3	Analyze the concepts Of AC & DC drives	-	3	-	-	-	-	-	-	-	-	-	-	-	2
1-Low		**2-Medium**											**3-High**		

Testing and commissioning of Electrical Equipments

[As per Choice Based Credit System (CBCS) & OBE Scheme]

SEMESTER VII

Course Code:	**P21EE7021**	**Credits:**	**03**
Teaching Hours/Week (L:T:P):	**4:0:0**	**CIE Marks:**	**50**
Total Number of Teaching Hours:	**40**	**SEE Marks:**	**50**

Course Learning Objectives (CLOs)

At the end of the course the students should have able to:

- Understand the concepts of installation of Transformers i.e. location, site selection, rating of machine, enquiry and storing of dispatched machine. And analyze different test which are conduct before commissioning of a transformer.
- Understand the concepts of installation of synchronous machine i.e. foundation details, cooling arrangements, excitation. And analyze different test which are conduct before commissioning of a synchronous machine.
- Understand the concepts of installation of Induction motor i.e. foundation details, alignment, coupling
- Analyze different test which are conducted on circuit breaker and its maintenance.

UNIT – I	**Transformers**	**8 Hours**

TRANSFORMERS: Power and distribution transformers specifications as per BIS standards.

Installation: Location, site, selection, foundation details (like bolts size, their number, etc), code of practice for terminal plates, polarity & phase sequence, oil tanks, drying of windings and general inspection.

Commissioning tests: Following tests as per national & International Standards, volt ratio test,earth resistance, oil strength, Bucholz & other relays, tap changing gear, fans & pumps, insulation test, impulse test, polarizing index, load & temperature rise test.

Self-study component:	Different types of transformer oil tanks

UNIT – II	**Synchronous Machines**	**8 Hours**

Specifications of synchronous machines

Installation: Physical inspection, foundation details, alignments, excitation systems, cooling and control gear, drying out.

Commissioning Tests: Insulation, Resistance measurement of armature & field windings,

Performance tests: Various tests to estimate the performance of generator operations, slip test, maximum lagging current, maximum reluctance power tests, sudden short circuit tests, transient & sub transient parameters, measurements of sequence impedances, capacitive reactance, and separation of losses, temperature rise test, and retardation tests. Various abnormal conditions and the respective Protection

Self-study component:	Selection of Motor

UNIT – III	Induction Motors	8 Hours

Specifications of induction motors & ratings

Installation: Location of the motors (including the foundation details) & its control apparatus, shaft & alignment for various coupling, fitting of pulleys & coupling, drying of windings.

Commissioning Test: Mechanical tests for alignment, air gap symmetry, tests for bearings, vibrations & balancing.

Electrical Tests: Insulation test, earth resistance, high voltage test, starting up, failure to speed up to take the load, type of test, routine test, factory test and site test (in accordance with ISI code).

Self-study component:	Maintenance of induction motor

UNIT – IV	Switch Gear & Protective Devices	8 Hours

Switch gear: Standards, types, specification, installation, commissioning tests, maintenance schedule, type & routine tests of Circuit breakers

Current transformer and Voltage transformer: Specifications, procurement, testing of CT and PT, Specifications and testing of cable

Self-study component:	Rating of circuit breaker

UNIT – V	Safety Management	8 Hours

Objectives of safety management, seven principles of safety management, work permit system, safety clearance and creepages, Safety procedures in eclectic plant, first aid, Electric shock, touch potential and step potential, recommended safety precautions against electric shock in small buildings, shops, and small LV installations Live line working (Hot line Maintenance), safety management during O and M.

Self-study component:	First aid its importance

Course Outcomes: On completion of this course, students are able to

COs	Course Outcomes with *Action verbs* for the Course topics	Bloom's Taxonomy Level	Level Indicator
CO1	Understand the basic concepts of Electrical equipments for installation and commissioning	Remember & Understand	L1, L2
CO2	Apply the knowledge of electrical science for the installation procedure of electrical equipments	Apply	L3
CO3	Analyze the different testing & commissioning procedure of electrical equipments	Analyze	L4

TEXT BOOKS:

1. Testing & Commissioning of Electrical Equipment -S.S. Rao, TMH, 6th Edition,2008
2. Testing & Commissioning of Electrical Equipment -Ramesh L. Chakrasali, Elite Publication.

REFERENCE BOOKS:

1. Relevant Bureau of Indian Standards
2. "A Handbook on Operation and Maintenance of Transformers"-H. N. S. Gowda,
3. Transformer & Switch GearHandbook -Transformers-BHEL, J &P, J & P

Course Outcomes		**Program Outcomes**												
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	Understand the basic concepts of Electrical equipment for installation and commissioning	3	-	-	-	-	-	2	-	-	-	-	2	2	-
2	Apply the knowledge of electrical science for the installation procedure of electrical equipments	3	-	-	-	-	-	2	-	-	-	-	-	2	-
3	Analyze the different testing & commissioning procedure of electrical equipments	-	3	-	-	-	-	2	-	-	-	-	-	2	-
1-Low		**2-Medium**												**3-High**	

Modern Control Theory

[As per Choice Based Credit System (CBCS) & OBE Scheme]

SEMESTER – VII

Course Code:	**P21EE7022**	**Credits:**	**03**
Teaching Hours/Week (L:T:P):	**3:0:0**	**CIE Marks:**	**50**
Total Number of Teaching Hours:	**40**	**SEE Marks:**	**50**

Course Learning Objectives: This course will enable the students to:

- Understand modeling in state space for different systems and analyze the state space representation using different canonical forms.
- Get the knowledge of solution of linear time invariant systems, state transition matrix, determination of state transition matrix using various techniques and analyze the controllability and observability of the system.
- Understand the basics of design of control system by pole placement technique, necessary & sufficient conditions for the design, determination of state feedback gain matrix using various methods and observer design.
- Understand the basics of non linear systems

UNIT – I	**Modeling in State Space**	**8 Hours**

Introduction, Limitations of classical control theory, Concept of State, State variables, State vector, State space, State-space equations and block diagram of the linear, continuous –time control system represented in state space, State space model for physical systems-electrical, mechanical and electro mechanical systems.

Self-study component:	state model by cascade programming.

UNIT – II	**State space representation, Controllability & Observability**	**8 Hours**

State space representations of transfer function systems: Canonical forms- Controllable, observable, and diagonal, Jordan canonical forms, Eigen values, diagonalization, invariance of Eigen values.

Concept of Controllability &Observability- Kalman's test and Gilbert's test, complete controllability& Observability in the s-plane, Sterilizability and Detectability.

Self-study component:	Principle of Duality

UNIT – III	**Solution of the linear time invariant state equation**	**8 Hours**

State transition matrix –properties, computation using Laplace transformation, power series, modal matrix &Cayley- Hamilton method, solution of homogeneous and non-homogenous state equations.

Self-study component:	linearization of state equation

UNIT – IV	**Design of control systems in state space**	**8 Hours**

Design of control systems in state space: Design by Pole Placement technique, stability improvements by state feedback, necessary & sufficient conditions for arbitrary pole placement, computation of feedback gain matrix by direct substitution, Ackermann's formula, and design of full order state observer.

Self-study component:	Design of Minimum order and reduced order state observer.	
UNIT – V	**Nonlinear systems**	**8 Hours**

Introduction to nonlinear systems, Characteristics of nonlinear systems, Common physical nonlinearities, Describing functions of non-linearities.

Self-study component:	Multi variable non linearity

Course Outcomes: On completion of this course, students are able to:

COs	**Course Outcomes** with ***Action verbs*** for the Course topics	**Bloom's Taxonomy Level**	**Level Indicator**
CO1	Understand the concepts of control system to do modeling in state space.	Remember & Understand	L1 & L2
CO2	Solution of the linear time invariant state equation and discuss the concept of controllability and observability.	Apply	L3
CO3	Analyze the functions of non linear systems.	Analyze	L4
CO4	Design of control system in state space	Design	L5

Text Book(s):

1. KatshuikoOgata"Modern Control Engineering", - 3rdedition 2002 & 5th Edition, 2012, PHI.
2. J Nagrath& M. Gopal,"Control Systems Engineering", New Age International Publishers, 5th Edition 2010.

Reference Book(s):

1. M Gopal "Digital Control & State variable methods", 3rd edition, TMH
2. Benjamin C Kuo, Farid Golnaraghi "automatic control systems,8th edition.

Web and Video link(s):

- https://www.youtube.com/watch?v=pbJ5xoeqMg0
- https://www.youtube.com/watch?v=xsvB1Y-JyhE
- https://www.youtube.com/watch?v=Q_cVJeK7MZw

E-Books/Resources:

- https://controltheorymaster.files.wordpress.com/2017/11/farid-golnaraghi-benjamin-c-kuo-automatic-control-systems.pdf

Course Outcomes		Program Outcomes													
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	Understand the concepts of control system to do modeling in state space.	3	-	-	-	-	-	-	-	-	-	-	2	2	-
2	Solution of the linear time invariant state equation and discuss the concept of controllability and observability.	3	-	-	-	-	-	-	-	-	-	-	-	2	-
3	Analyze the functions of nonlinear systems.	-	3	-	-	-	-	-	-	-	-		-	2	-
4	Design of control system in state space	-	-	2	-	-	-	-	-	-	-	-	-	2	-
1-Low				**2-Medium**									**3-High**		

Power system operation and control [As per Choice Based Credit System (CBCS) & OBE Scheme] SEMESTER – VII			
Course Code:	**P21EE7023**	**Credits:**	**03**
Teaching Hours/Week (L:T:P):	**4:0:0**	**CIE Marks:**	**50**
Total Number of Teaching Hours:	**40**	**SEE Marks:**	**50**

Course Learning Objectives: This course will enable the students to:

- Get the overview of computer control centers for power systems.
- Understand the methods of controlling power generation.
- Study the methods of controlling reactive power.
- Study the need of Unit commitment.
- Understand about power system security

UNIT – I	**Control center operation of power systems**	**8 Hours**

Introduction: Operating States of Power System, Objectives of Control, Key Concepts of Reliable Operation, Preventive and Emergency Controls, Energy Management Centers.

Supervisory Control and Data Acquisition (SCADA): Introduction, components, application in Power System, basic functions and advantages. Building blocks of SCADA system, components of RTU, communication subsystem, IED functional block diagram.

Self-study component:	Classification of SCADA system

UNIT – II	**Automatic Generation Control**	**8 Hours**

Automatic control loops of generators: AGC and AVR. Automatic Load Frequency Control (ALFC/LFC) of single area systems-turbine speed governing system, turbine model, generator- load model, Complete block diagram of representation of load frequency control of an isolated power system, steady state analysis, dynamic response, concept of control area, Automatic voltage regulator.

Self-study component:	load frequency control of two area systems

UNIT – III	**Control of voltage and Reactive Power**	**8 Hours**

Introduction, sending and receiving end voltages in terms of power and reactive power, generation and absorption of reactive power, relation between voltage, power and reactive power at a node, methods of voltage control-Injection of Reactive Power: shunt capacitors and reactors, series capacitor, synchronous compensator, static VAR compensator and STATCOMs, Tap-Changing Transformers, Voltage collapse.

Self-study component:	Voltage control in Distribution Network

UNIT – IV	**Unit Commitment**	**8 Hours**

Introduction, need and importance of unit commitment, constraints in unit commitment: spinning reserve, Thermal unit constraints, other constraints problems on priority list method, Methods of

Unit commitment -priority lists method.		
Self-study component:	Dynamic programming solution	
UNIT – V	**Power system security**	**8 Hours**
Introduction, factors affecting power system security, Power system contingency analysis, Detection of network problems, network sensitivity methods, calculation of network sensitivity factor, contingency ranking.		
Self-study component:	Concentric relaxation	

Course Outcomes: On completion of this course, students are able to:

COs	**Course Outcomes** with ***Action verbs*** for the Course topics	**Bloom's Taxonomy Level**	**Level Indicator**
CO1	Understand the concept of power system to control them under various conditions.	Remember & Understand	L1, L2
CO2	Apply the different methods to find solution of Unit commitment.	Apply	L3
CO3	Analyze the different methods of AGC and AVR.	Analyze	L4
CO4	Analyze different power system security issues in order to solve network problems.	Analyze	L4

Text Book(s):

1. "Power generation, operation and control" by: Allen J.Wood & B F Woollenberg. John Wiley and Sons, Publications II-Edition 2010.
2. "Computer Aided Power System Analysis", by: G.L. Kusic, PHI,2010
3. "Electric Power Systems", by: B. M. Weedy, B.J. Cory, Wiley, 5th Edition, 2010.
4. Power System SCADA and Smart Grid, Mini S Thom and John D. McDonald, CRC Press 2015.

Reference Book(s):

1. "Modern Power System Analysis", by D.P. Kothari and I.J. Nagrath, Third Edition, Tata-McGrawHillPublishingCompanyLimited,NewDelhi,2010.
2. Power System Operation and Control, K. Uma Rao, Wiley, 1st Edition, 2012

Web and Video link(s):

- https://youtu.be/KQSQTl2EEa4?si=QDAU59GwOQnEecZI
- https://youtu.be/iiWj-eJd1Sk?si=IuxbvCNt0o7SGBHb
- https://youtu.be/enaFuzxGgmg?si=mwJf5-1ltRarQU1w

E-Books/Resources:

- http://powerunit-ju.com/wp-content/uploads/2016/11/Power-System-Analysis-by-Hadi-Saadat-Electrical-Engineering-libre.pdf
- https://books.google.com/books/about/Power_System_Analysis.html?id=NBIoAQAAMAAJ

Course Outcomes		Program Outcomes													
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	Understand the concept of power system to control them under various conditions.	3	-	-	-	-	-	-	-	-	-	-	2	2	-
2	Apply the different methods to find solution of Unit commitment.	3	-	-	-	-	-	-	-	-	-	-	-	2	-
3	Analyze the different methods of AGC and AVR.	-	3	-	-	-	-	-	-	-	-	-	-	2	-
4	Analyze different power system security issues in order to solve network problems.	-	3	-	-	-	-	-	-	-	-	-	-	2	-
1-Low				**2-Medium**									**3-High**		

Electric Vehicles [As per Choice Based Credit System (CBCS) & OBE Scheme] SEMESTER – VII			
Course Code:	**P21EE7024**	**Credits:**	**03**
Teaching Hours/Week (L:T:P):	**3:0:0**	**CIE Marks:**	**50**
Total Number of Teaching Hours:	**40**	**SEE Marks:**	**50**

Course Learning Objectives: This course will enable the students to:

- Understand the concepts of Electric Vehicles (EVs), Hybrid Electric Vehicles (HEVs), and their components.
- Compare Electric Vehicles (EVs) with Internal Combustion Engine Vehicles (ICEVs) and understand their respective architectures.
- Understand the concepts of of BMS.
- Types of Electric Motors: DC Motors, Induction Motors, Brushless DC Motors, Switched Reluctance Motors
- Domestic Charging Infrastructure for Electric Vehicles

UNIT – I	**Introduction to Alternative Vehicles & Architectures**	**8 Hours**

Electric Vehicles, Hybrid Electric Vehicles, Electric and Hybrid Vehicle Components, Vehicle Mass and Performance, Electric Motor and Engine Ratings, Electric and Hybrid Vehicle History, EV/ICEV Comparison, Electric Vehicles Architectures, Hybrids Based on Architecture, Plug-In Hybrid Electric Vehicle.

Self-study component:	Latest trend in EV

UNIT – II	**Battery Energy Storage**	**8 Hours**

Batteries: Lead Acid Battery, Nickel based batteries, Sodium based batteries, Lithium based batteries – Li-ion & Li-poly, Metal Air Battery, Zine Chloride battery; Ultra capacitors; Flywheel Energy Storage System; Hydraulic Energy Storage System; Comparison of different Energy Storage System.

Self-study component:	Future of Battery technology

UNIT – III	**Batteries for Electric Vehicles**	**8 Hours**

Selection of battery for EVs & HEVs, Traction Battery Pack design, Requirement of Battery Monitoring, Battery State of Charge Estimation methods, Battery Cell equalization problem, thermal control, protection interface, SOC Estimation, Energy & Power estimation, Battery thermal management system, Battery Management System: Definition, Parts: Power Module, Battery, DC/DC Converter, load, communication channel, Battery Pack Safety.

Self-study component:	Battery Standards & Tests.

UNIT – IV	**Electric Machines**	**8 Hours**

Principle of Operation and Performance: DC Motor Drives, Induction Motor Drives, Permanent Magnetic Brush-Less DC Motor Drives, Switched Reluctance Motor Drives

Self-study component:	Special Electrical Machines for EV applications	
UNIT – V	**EV Charging Infrastructure**	**8 Hours**

Domestic charging infrastructure, Public charging infrastructure: Normal charging stations, Occasional charging stations, Fast charging stations, Battery swapping stations, Move-and-charge zones, Payment systems.Standardization and regulations, Training and promotion, Impacts on power system: Harmonic impact, Harmonic compensation, Current demand impact, Current demand minimization.

Self-study component:	Policies and regulations for EV vehicles

Course Outcomes: On completion of this course, students are able to:

COs	**Course Outcomes** with ***Action verbs*** for the Course topics	**Bloom's Taxonomy Level**	**Level Indicator**
CO1	Illustrate the fundamental concepts and components of Electric Vehicles (EVs) including their architectures and key differences from traditional vehicles.	Remember & Understand	L1&L2
CO2	Apply the knowledge of battery technologies, motors and charging infrastructure of EV to study electric and hybrid vehicle applications.	Apply	L3
CO3	Analyze the performance of various batteries, electric machines, vehicle components, and evaluating their suitability for different types of electric vehicle architectures.	Analyze	L4

Text Book(s):

1. Electric and Hybrid Vehicles: Design Fundamentals Iqbal Husain CRC Press 2003
2. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design M. Ehsani, Y. Gao, S. Gay and Ali Emadi CRC Press 2005
3. AK Bandyopadhyay, Nanomaterials , New Age International (P) Ltd., 2nd Edition, 2010.

Reference Book(s):

1. Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles Sheldon S. Williamson Springer 2013
2. Chan, C.C._ Chau, K.T. - Modern Electric Vehicle Technology-Oxford University Pres
3. Pistoia, J.P. Wiaux, S.P. Wolsky, Used Battery Collection and Recycling, Elsevier, 2001
4. Arno Kwade, Jan Diekmann, Recycling of Lithium-Ion Batteries: The LithoRec Way, Springer, 2018.

Course Outcomes		Program Outcomes													
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	Illustrate the fundamental concepts and components of Electric Vehicles (EVs) including their architectures and key differences from traditional vehicles.	3	-	-	-	-	-	-	-	-	-	-	2	2	-
2	Apply the knowledge of battery technologies, motors and charging infrastructure of EV to study electric and hybrid vehicle applications.	3	-	-	-	-	-	-	-	-	-	-	2	2	-
3	Analyze the performance of various batteries, electric machines, vehicle components, and evaluating their suitability for different types of electric vehicle architectures.	-	3	-	-	-	-	-	-	-	-	-	-	2	-
1-Low					**2-Medium**									**3-High**	

ENERGY AUDITING & DEMAND SIDE MANAGEMENT
[As per Choice Based Credit System (CBCS) & OBE Scheme]
SEMESTER – VII

Course Code:	**P21EE7031**	**Credits:**	**03**
Teaching Hours/Week (L:T:P):	**4:0:0**	**CIE Marks:**	**50**
Total Number of Teaching Hours:	**40**	**SEE Marks:**	**50**

Course Learning Objectives: This course will enable the students to:

- Energy situation in the world and in India, Time value of money concept, Developing cashflow models, Payback analysis, taxes and tax credits, concept of ABT.
- Energy audit, presentation of energy audit results, measurements in energy audit.
- Power factor correction, energy efficient motors and lighting basics.
- Concept of DSM, benefits of DSM, Different

UNIT – I	**Introduction**	**8 Hours**

Introduction: Energy Sources-Primary & Secondary sources, Commercial & noncommercial sources, Renewable &Nonrenewable sources. Energy situation in the world and India, Energy consumption, Energy Conservation- Three Pronged Approach to Energy Management, Electrical distribution Codes, standards for electrical equipment, regulations, other legal Provisions and Legislation.

Energy Economic Analysis: The time value of money concept, Interest, Types of interest, present worth & future worth. Developing cash flow models, payback analysis, advantages and disadvantages of payback analysis, depreciation, methods of depreciation, Concept of ABT, broad features of ABT design and numerical problem.

Self-study component:	Taxes and tax-credit

UNIT – II	**Energy Auditing**	**8 Hours**

Introduction, Definition & objectives of Energy Management, Principles of management, Energy management strategy, Elements of energy audits, energy audit: types and methodology, preliminary audit and detailed audit, role of energy management team, energy audit reporting format, energy use profiles, Audits required to construct the energy use profiles, measurements in energy audits, energy audit instruments

Self-study component:	Electrical System Optimization

UNIT – III	**Electrical Equipment and power factor correction**	**8 Hours**

Power factor improvement-Power factor, causes of low power factor, advantages of high power factor, disadvantages of low power factor, Power factor improvement equipment-static capacitors, synchronous condenser, and phase advancers. Calculation of power factor correction, importance of power factor improvement, most economical power factor, location & sizing of capacitors, energy efficient motors, Numerical on power factor correction.

Self-study component:	Lighting basics	
UNIT – IV	**Demand Side Management**	**8 Hours**

Introduction to DSM, concept of DSM, benefits of DSM,DSM planning and implementation, different techniques of DSM–time of day pricing and metering, multiutility power exchange model, load management, Load priority technique- direct load control technique, local load control technique, distributed load control technique.

Self-study component:	Energy efficient technology in electrical system.

UNIT – V	**Load management**	**8 Hours**

Peak clipping, load shifting, valley filling, strategic energy conservation, strategic load growth, flexible load shape, energy efficiency improvement, Different time zones, Tariff option for DSM-time of day tariff, seasonal tariff, curtailable tariff, End use energy conservation, customer acceptance of DSM, DSM implementation issues, DSM implementation strategies, Management and Organization of Energy Conservation awareness Programs- Plant level, Division level, corporate level.

Self-study component:	Energy efficient lighting controls and Integrated energy policy

Course Outcomes: On completion of this course, students are able to

COs	**Course Outcomes** with ***Action verbs*** for the Course topics	**Bloom's Taxonomy Level**	**Level Indicator**
CO1	Demonstrate comprehension of the fundamental principles and objectives of energy management and recognizing the significance of energy auditing.	Understand and Remember	L1, L2
CO2	Apply power factor correction techniques and demand side management strategies to optimize electrical systems	Apply	L3
CO3	Analyze the economic aspects of energy management, including conducting energy economic	Analyze	L4

Text Book(s):

1. "Fundamentals of Energy Engineering" - Albert Thumann, Prentice Hall Inc, Englewood Cliffs, New Jersey.
2. Electrical distribution – Pabla, TMH Publishers, 2004.

Reference Book(s):

1. "Demand Side Management"-Jyothi Prakash, , TMH Publishers, 2000.
2. Hand book on energy auditing - TERI (Tata Energy Research)
3. Principles of Power system V.K. Mehtha, ,S.Chand& Company Ltd. 2002
4. Hand book of Electrical power Distribution, Gorti Ramamurthy, University press, 2nd edition, 2009

Course Outcomes		Program Outcomes													
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	Demonstrate comprehension of the fundamental principles and objectives of energy managemen and recognizing the significance of energy auditing.	3	-	-	-	-	-	-	-	-	-	-	2	1	-
2	Apply power factor correction techniques and demand side management strategies to optimize electrical systems	3	-	-	-	-	-	-	-	2	2	-	2	1	-
3	Analyze the economic aspects of energy management, including conducting energy economic	-	3	-	-	-	-	-	-	2	2	-	2	-	1
1-Low				**2-Medium**										**3-High**	

Smart Grid [As per Choice Based Credit System (CBCS) & OBE Scheme] SEMESTER – VII			
Course Code:	**P21EE7032**	**Credits:**	**03**
Teaching Hours/Week (L:T:P):	**3:0:0**	**CIE Marks:**	**50**
Total Number of Teaching Hours:	**40**	**SEE Marks:**	**50**

Course Learning Objectives: This course will enable the students to:

- Performance Analysis Tools for Smart Grid Design
- Analysis Techniques for Steady-State Voltage Stability Studies
- Computational Tools, Decision Support Tools, Optimization Techniques
- Case Studies and Test beds for the Smart Grid

UNIT – I	**Introduction**	**8 Hours**

Smart Grid Architectural Designs: Introduction, Today's Grid versus the Smart Grid, Energy Independence and Security Act of 2007: Rationale for the Smart Grid, Computational Intelligence, Power System Enhancement, Communication and Standards, Environment and Economics, General View of the Smart Grid Market Drivers, Stakeholder Roles and Function, Working Definition of the Smart Grid Based on Performance Measures, Representative Architecture, Functions of Smart Grid Components. Smart Grid Communications and Measurement Technology: Communication and Measurement, Monitoring, PMU, Smart Meters, and Measurements Technologies, GIS and Google Mapping Tools, Multi agent Systems (MAS) Technology.

Performance Analysis Tools for Smart Grid Design: Introduction to Load Flow Studies, Challenges to Load Flow in Smart Grid and Weaknesses of the Present Load Flow Methods, Load Flow State of the Art: Classical, Extended Formulations, and Algorithms, Congestion Management Effect, Load Flow for Smart Grid Design, DSOPF Application to the Smart Grid, Static Security Assessment (SSA) and Contingencies, Contingencies and Their Classification.

Self-study component:	Microgrid and Smart Grid Comparison, Contingency Studies for the Smart Grid.

UNIT – II	**Stability Analysis Tools for Smart Grid**	**8 Hours**

Introduction to Stability, Strengths and Weaknesses of Existing Voltage Stability Analysis Tools, Voltage Stability Assessment, Voltage Stability Assessment Techniques, Voltage Stability Indexing, Analysis Techniques for Steady-State Voltage Stability Studies, Application and Implementation Plan of Voltage Stability, Optimizing Stability Constraint through Preventive Control of Voltage Stability, Angle Stability.

Self-study component:	Assessment, State Estimation.

UNIT – III	**Computational Tools for Smart Grid Design**	**8 Hours**

Introduction to Computational Tools, Decision Support Tools, Optimization Techniques, Classical Optimization Method, Heuristic Optimization, Evolutionary Computational Techniques, Adaptive Dynamic Programming Techniques, Pareto Methods, Hybridizing Optimization Techniques and

Applications to the Smart Grid, Computational Challenges. Pathway for Designing Smart Grid: Introduction to Smart Grid Pathway Design, Barriers and Solutions to Smart Grid Development, Solution Pathways for Designing Smart Grid Using Advanced Optimization and Control Techniques for Selection Functions, General Level Automation, Bulk Power Systems Automation of the Smart Grid at Transmission Level, Distribution System Automation Requirement of the Power Grid, End User/Appliance Level of the Smart Grid.		
Self-study component:	Applications for Adaptive Control and Optimization	
UNIT – IV	**Renewable Energy and Storage**	**8 Hours**
Renewable Energy Resources, Sustainable Energy Options for the Smart Grid, Penetration and Variability Issues Associated with Sustainable Energy Technology, Demand Response Issues, Electric Vehicles and Plug-in Hybrids, PHEV Technology, Environmental Implications, Storage Technologies, Tax Credits. Interoperability, Standards, and Cyber Security: Introduction, Interoperability, Standards, Smart Grid Cyber Security.		
Self-study component:	Cyber Security and Possible Operation for Improving Methodology for Other Users.	
UNIT – V	**Research, Education, and Training for the Smart Grid**	**8 Hours**
Introduction, Research Areas for Smart Grid Development, Research Activities in the Smart Grid, Multidisciplinary Research Activities, Smart Grid Education, Training and Professional Development. **Case Studies and Test beds for the Smart Grid**: Introduction, Demonstration Projects, Advanced Metering, Microgrid with Renewable Energy, Power System Unit Commitment (UC) Problem, ADP for Optimal Network Reconfiguration in Distribution Automation, Case Study of RER Integration, Test beds and Benchmark Systems.		
Self-study component:	Challenges of Smart Transmission, Benefits of Smart Transmission	

Course Outcomes: On completion of this course, students are able to

COs	**Course Outcomes** with ***Action verbs*** for the Course topics	**Bloom's Taxonomy Level**	**Level Indicator**
CO1	Illustrate the fundamental principles and technologies underlying the Smart Grid.	Understand and Remember	L1, L2
CO2	Apply computational tools and optimization techniques to manage Smart Grid systems, for addressing challenges in renewable energy integration, demand response, and grid stability.	Apply	L3
CO3	Analyze the challenges, interoperability issues, and cyber security concerns associated with Smart Grid implementation.	Analyze	L4

Text Book(s):

1. Smart Grid, Fundamentals of Design and Analysis James Momoh Wiley 1st Edition, 2012

Course Outcomes		Program Outcomes													
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	Illustrate the fundamental principles and technologies underlying the Smart Grid.	3	-	-	-	-	-	-	-	-	-	-	-	2	-
2	Apply computational tools and optimization techniques to manage Smart Grid systems, for addressing challenges in renewable energy integration, demand response, and grid stability.	3	-	-	-	-	-	-	-	-	-	-	-	2	-
3	Analyze the challenges, interoperability issues, and cyber security concerns associated with Smart Grid implementation.	-	3	-	-	-	-	-	-	-	-	-	-	2	-
1-Low					**2-Medium**									**3-High**	

HVDC Power Transmission [As per Choice Based Credit System (CBCS) & OBE Scheme] SEMESTER – VII			
Course Code:	**P21EE7033**	**Credits:**	**03**
Teaching Hours/Week (L:T:P):	**4:0:0**	**CIE Marks:**	**50**
Total Number of Teaching Hours:	**40**	**SEE Marks:**	**50**

Course Learning Objectives: This course will enable the students to:

- Comparison of DC transmission with respect to AC transmission
- Analysis of converters – assumptions, characteristics & Properties
- Analysis of Gratez circuit (rectification & inversion)
- To study the control strategies involved in DC Transmission
- To know about the role of protection, harmonics & filters in DC transmission

UNIT – I	**General Aspects of DC Transmission and Comparison with AC Transmission**	**8 Hours**

Historical sketch, Types of DC links, Comparison of AC and DC transmission, Description of DC transmission systems, Principal applications of DC transmission, Modern Trends in HVDC Technology, Planning for HVDC Transmission.

Self-study component:	HVDC transmission based on VSC

UNIT – II	**Converter circuits**	**8 Hours**

Valve characteristics, Properties of converter circuits, Assumptions, Single phase converters, Pulse number, Three phase converters; one way and two way (6 pulse)converters, Circuit of Twelve pulse cascade of two bridges with waveforms (Characteristics and analysis are excluded)

Self-study component:	Additional six pulse converter circuits

UNIT – III	**Analysis of Three phase bridge converter**	**8 Hours**

Analysis with grid control without overlap; current and phase relations, Analysis with grid control and overlap less than 60˚; voltage reduction due to commutation overlap, Mode 1, Mode 2 and Mode 3 operation, Vd-Id Characteristics of Converter, Inversion.

Self-study component:	Series and parallel arrangements of valves, anodes or bridges

UNIT – IV	**Control strategies**	**8 Hours**

Basic means of control, Power reversal, Limitations of manual control, Constant voltage versus constant current control, desired features of control, Actual control characteristics, Constant minimum ignition angle control, Constant current control, Stability of control, MTDC systems (configurations only)

Self-study component:	Constant extinction angle control, Tap changer control, power control and current limits

UNIT – V	Protection & Harmonics	8 Hours

Protection: General, Prevention of consequent commutation failures, Converter faults, DC Circuit breakers, Clearing line faults and re-energizing the line.

Characteristic and Uncharacteristic harmonics, Telephone interference, Troubles caused by harmonics, Means of reducing harmonics, Harmonic filters.

Self-study component:	DC reactors

Course Outcomes: On completion of this course, students are able to:

COs	Course Outcomes with *Action verbs* for the Course topics	Bloom's Taxonomy Level	Level Indicator
CO1	Illustrate the General Aspects of DC Transmission on par with AC transmission.	Remember & Understand	L1 &L2
CO2	Apply the knowledge of transmission system to study the operation of different converts in HVDC transmission.	Applying	L3
CO3	Analyze the performance characteristics of different converter circuits used in HVDC transmission.	Analyzing	L4

Text Book(s):

1. Direct Current Transmission, E. W. Kimbark, - Volume I, Wiley futerscience, 1971
2. Power System Stability and Control, Prabha Kundur , Tata McGraw Hill, 9th Reprint, 2007.

Reference Book(s):

1. HVDC Power transmission systems - Technology and System Interactions, K. R. Padiyar, Wile Eastern Limited, 1992.
2. High voltage direct current transmission, J. Arrillaga, 2nd edition, 2007

Course Outcomes		Program Outcomes													
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	Illustrate the General Aspects of DC Transmission on par with AC transmission.	3	-	-	-	-	-	-	-	-	-	-	2	2	-
2	Apply the knowledge of transmission system to study the operation of different converts in HVDC transmission.	3	-	-	-	-	-	-	-	-	-	-	-	2	-
3	Analyze the performance characteristics of different converter circuits used in HVDC transmission.	-	3	-	-	-	-	-	-	-	-	-	-	2	-
1-Low		**2-Medium**												**3-High**	

Artificial Neural Networks & Artificial Intelligence

[As per Choice Based Credit System (CBCS) & OBE Scheme]

SEMESTER – VII

Course Code:	**P21EE7034**	**Credits:**	**03**
Teaching Hours/Week (L:T:P):	**3:0:0**	**CIE Marks:**	**50**
Total Number of Teaching Hours:	**40**	**SEE Marks:**	**50**

Course Learning Objectives: This course will enable the students to:

- Understand the different terminologies used in Artificial Neural Network.
- Study the different learning rules in ANN.
- Understand the architecture and algorithm of various neural networks.

UNIT – I	**Introduction**	**8 Hours**

Human Brain, Biological Neuron networks –Artificial Neural networks (ANN). Comparison between ANN and Biological Neuron networks. Architectures- Feed forward and Feedback architecture. Supervised, Unsupervised and Reinforcement leaning. ANN terminologies: Weights, Activation functions-Sigmoidal functions, Bias, Threshold.

Fundamental models of ANN & Learning Processes:

McCulloch-Pitts (MP) neuron model – Architecture (MP model on AND, OR, NOT and EXOR gates only). Learning rules: Hebbian learning rule, Perception Learning rules, delta Learning rules, Competitive learning, Boltzmann learning, Memory-based learning.

Self-study component:	Generate AND, NOT function using MP neural net by MATLAB.

UNIT – II	**Architecture and Algorithms of ANN**	**8 Hours**

Hebb net – architecture, algorithm (Excluding problems)**,** Perceptron Networks-Single Layer Perceptron: Architecture, algorithm, Application procedure. Perceptron algorithm for several output classes (Excluding problems). Brief introduction to Multi-Layer Perceptron networks.

Adaline and Madline networks- Adaline networks-Architecture, algorithm, Application procedure (Excluding problems) and Madline networks Architecture, algorithm, and Application procedure (Excluding problems).

Self-study component:	Develop MATLAB program for AND & OR function by using perceptron and adaline net.

UNIT – III	**Feedback and Feed forward networks**	**8 Hours**

Feedback networks: Discrete Hopfield Net –architecture, training algorithm, application algorithm, analysis. Continuous Hopfield Net. Bi-directional Associative Memory (BAM)(Excluding problems).Relation between BAM & Hopfield Net.

Feed forward networks: Introduction, Back Propagation Network (BPN), - Generalized Delta learning rule (or) Back Propagation rule-Architecture, training algorithm, selection parameters, learning in Back Propagation (Excluding problems). Merits and Demerits of Back Propagation

Network (BPN), Applications. Radial-Basic Function Networks (RBFN):Architecture, Training algorithm for a RBFN (Excluding problems).		
Self-study component:	Develop a MATLAB program for approximating a two 2-dimensional functions using back propagation in batch mode.	
UNIT – IV	**Self-organizing feature Map and ART**	**8 Hours**
Self-organizing feature Map (SOM): Kohonen Self-organizing feature Map (SOM)- Architecture, training algorithm). Learning vector quantization (LVQ) - Architecture, training algorithm (Excluding problems). **Adaptive Resonance Theory (ART)**: ART fundamentals, Basic architecture, Basic operation, Learning in ART. Basic training steps. ART1 - Architecture, training algorithms, ART2- Architecture and training algorithm (Excluding problems)		
Self-study component:	Applications of ART1 and ART2	
UNIT – V	**Introduction to Artificial Intelligence**	**8 Hours**
Artificial Intelligence, Goals of AI, AI Technique, Applications of AI, Types of Intelligence, Working of Speech and Voice Recognition Systems, AI - Agents & Environments, Agent Terminology, Types of Agents- Rational Agent, Simple and Model based Reflex Agents, Goal Based Agents, Utility Based Agents, Properties of Environment, different AI- Search Terminology (Meaning only). **Artificial Intelligence – Robotics:** Robotics, Robot Locomotion- Legged Locomotion, Wheeled Locomotion, Slip/Skid Locomotion, Components of a Robot, Applications of Robotic		
Self-study component:	Brute-Force Search Strategies, Informed (Heuristic) Search Strategies	

Course Outcomes: On completion of this course, students are able to

COs	**Course Outcomes** with ***Action verbs*** for the Course topics	**Bloom's Taxonomy Level**	**Level Indicator**
CO1	Illustrate the knowledge of allied engineering to analyze the different terminologies used in Artificial Neural Network and AI	Understand and Remember	L1, L2
CO2	Apply the knowledge of different learning rules to study the architecture of ANN and AI techniques.	Apply	L3
CO3	Analyze the architecture, algorithm of various neural networks and agents on AI.	Analyze	L4

Text Book(s):

1. "Introduction to Artificial Neural networks" .By: S N Sivanandum, S Sumathi& S N Deepa. Tata McGraw Hill publications.Year-2014
2. "Principals of Soft-computing" – By: S N Shivanadum, & S N Deepa. Wiley Eastern (India)

Ltd. - publication.Year- 2013.
3. Stuart Russel, Peter Norvig "AI - A Modern Approach", 2nd Edition, Pearson Education 2007
4. 4. Peter Jackson, "Introduction to Expert Systems", 3rd Edition, Pearson Education, 2007

Reference Book(s):

1. "Neural Networks and Fuzzy Systems", by: Bart Kosko. PHI - publications.Year-2014.
2. Artificial Intelligence: The Basics 1st Edition by by Kevin Warwick.
3. Artificial Intelligence: Foundations of Computational Agents, 2nd Edition*By David L. Poole and Alan K. Mackworth*

Course Outcomes		**Program Outcomes**													
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	Illustrate the knowledge of allied engineering to analyze the different terminologies used in Artificial Neural Network and A	3	-	-	-	-	-	-	-	2	2	-	2	-	-
2	Apply the knowledge of differen learning rules to study the architecture of ANN and AI techniques.	3	-	-	-	-	-	-	-	2	2	-	2	-	-
3	Analyze the architecture, algorithm of various neural networks and agents on AI.	-	3	-	-	-	-	-	-	2	2	-	2	-	-
1-Low		**2-Medium**											**3-High**		

High Voltage Engineering (Integrated)

[As per Choice Based Credit System (CBCS) & OBE Scheme]

SEMESTER – VII

Course Code:	**P21EE704**	**Credits:**	**04**
Teaching Hours/Week (L:T:P):	**3:0:2**	**CIE Marks:**	**50**
Total Number of Teaching Hours:	**50**	**SEE Marks:**	**50**

Course Learning Objectives: This course will enable the students to:

- Students will understand the Breakdown phenomenon in gaseous, solids and liquid Dielectrics.
- Students will learn basic need to generate high voltages such as HVAC, HVDC, Impulse Voltages and Impulse Currents in the laboratory.
- Students gain the fundamental knowledge of physical phenomena of breakdown in insulating media and students will know the importance of insulating media and their applications in various fields.
- Students will learn how to measure the high voltages in the laboratory
- Students will know importance of testing and learn procedure of testing different insulating media for accessing their condition

UNIT – I	**Introduction**	**8 Hours**

Introduction: Introduction to HV technology, Need for generating high voltages in laboratory. Important applications of high voltage.

Breakdown phenomena: Classification of HV insulating media. Gaseous dielectrics: Ionizations, primary and secondary ionization processes. Criteria for gaseous insulation breakdown - Townsend's theory, limitations of Townsend's theory, Streamer's theory, Corona discharges,Paschen's law and its significance, Time lags of Breakdown. Breakdown in solid dielectrics- Intrinsic breakdown, Thermal breakdown and Electro-mechanical breakdown. Breakdown of liquids dielectrics- Suspended particle theory, Cavity breakdown (bubble's theory).

Self-study component:	Breakdown in electro-negative gases
Practical	a. Breakdown characteristics of liquid insulation

UNIT – II	**Generation of HVAC and HVDC Voltages**	**8 Hours**

Generation of HVAC and HVDC Voltages: HVAC - HV transformer; Need for cascade connection and working of transformer units connected in cascade, Series resonant circuit, Tesla coil. HVDC - Cockcroft- Walton type high voltage DC set. Regulation, Ripple and Optimum number of stages.

Self-study component:	Voltage doubler circuit
Practical	b. Spark over characteristics of air insulation subjected to HVAC

	for uniform and non- uniform fields	
UNIT – III	**Generation of Impulse Voltage and Current**	**8 Hours**
Generation of Impulse Voltage and Current: Introduction to standard lightning and switching impulse voltages. Multistage impulse generator - working of Marx impulse generator, Rating of impulse generator, Components of multistage impulse generator, Triggering of impulse generat		
Self-study component:	Triggering of impulse generator by three electrode gap arrangement	
Practical	c. To determine 50% probability flashover voltage using impulse generator	
UNIT – IV	**Measurement of High Voltages**	**8 Hours**
Measurement of High Voltages: Electrostatic voltmeter - principle, construction and limitation; Chubb and Fortescue method for HVAC measurement, Generating voltmeter- Principle & Construction; Series resistance micro ammeter for HVDC measurements, Standard sphere gap measurements for HVAC, HVDC and Impulse voltages; Factors affecting the measurements: Potential dividers - Resistance dividers, Capacitance dividers.		
Self-study component:	Surge current measurement - Klydanograph and Magnetic link.	
Practical	d. Spark over characteristics of air insulation subjected to HVDC for uniform and non- uniform fields	
UNIT – V	**Non-destructive Insulation Testing Techniques**	**8 Hours**
Non-destructive Insulation Testing Techniques: Dielectric loss and loss angle measurements using Schering Bridge, Need for discharge detection, PD measurements – aspects, factors affecting the discharge detection; Discharge detection methods - Straight and Balanced methods. **High Voltage Tests on Electrical Apparatus**: Tests on Circuit breakers and Transformers.		
Self-study component:	Tests on Cables and Insulators	
Practical	e. Partial Discharge characteristics at low pressures using vacuum system and high pressure chamber.	

Course Outcomes: On completion of this course, students are able to

COs	**Course Outcomes** with ***Action verbs*** for the Course topics	**Bloom's Taxonomy Level**	**Level Indicator**
CO1	Illustrate the basic knowledge of electric laws and principles to study the Phenomena of Breakdown in different Dielectrics, generation and measuring of high voltage	Understand and Remember	L1, L2
CO2	Apply the knowledge of breakdown phenomenon of to study the HVAC, HVDC and impulse voltage generation processes	Apply	L3
CO3	Analyze voltage Tests on Electrical Apparatus and Non-destructive Insulation Testing Techniques	Analyze	L4

CO4	Conduct experiments to analyze the operation of relays ,protection scheme for generator, HVAC and HVDC	Analyze	L4

Text Book(s):

1. High Voltage Engineering Fundamentals- E. Kuffel and W.S. Zaengl, Elsevier press, - 2ndEdition, 2005.
2. High Voltage Engineering- M.S.Naidu and Kamaraju, THM, - 3rdEdition,2007.

Reference Book(s):

1. High Voltage Engineering - C.L.Wadhwa, New Age International Private limited, 1995.
2. Extra High Voltage AC Transmission Engineering -Rakosh Das Begamudre, Wiley Eastern limited, 1987.
3. 3. High Voltage Technology- L. L. Alston- BSB Publication, 1st Edition, 2008.

Course Outcomes		**Program Outcomes**												
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	Illustrate the basic knowledge of electric laws and principles to study thePhenomena ofBreakdownindifferentDielectris, generation and measuring of high voltage	3	-	-	-	-	-	-	-	2	2	-	2	-	-
2	Apply the knowledge of breakdown phenomenon of to study the HVAC, HVDC and impulse voltage generation processes	3	-	-	-	-	-	-	-	2	2	-	2	-	-
3	Analyze voltageTestsonElectricalApparatus and Non-destructive Insulation Testing Techniques	-	3	-	-	-	-	-	-	2	2	-	2	-	-
4.	Conduct experiments to analyze the operation of relays ,protection scheme for generator, HVAC and HVDC	3	3	-	3	1	-	-	2	2	2		2	-	-
1-Low		**2-Medium**											**3-High**		