K. K. Wagh Institute of Engineering Education and Research, Nashik
(Autonomous from Academic Year 2022-23)

T.Y. B.Tech. Pattern:2023 Semester: V (Electrical Engineering) 2306301: Control System Engineering		
Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Theory: 3 Hrs./Week	**TH: 3**	**Continuous Comprehensive Evaluation: 20Marks** **In Sem Exam: 20 Marks** **End Sem Exam: 60Marks**

Prerequisite Courses: Advanced Calculus and Transform Techniques, Electrical Network Analysis

Course Objectives: The objectives of the course are to
1. Impart a basic understanding of control system engineering
2. Introduce basic terminologies and principles of control system engineering
3. Acquaint students with the time-domain and frequency-domain methods for determining the stability of the system
4. Present fundamental controller design methods typically used in industries

Course Outcomes: On completion of the course, students will be able to–

	Course Outcomes	Bloom's Level
CO1	Define various terminologies in the control system.	2-Understand
CO2	Sketch the root locus, Bode plot, polar plot and Nyquist plot of the system	3- Apply
CO3	Analyze system stability using time-domain and frequency-domain Techniques	4-Analyze
CO4	Evaluate transfer function, error constants, GM, PM, PID Parameters, controllability and observability matrices of the system	5-Evaluate

COURSE CONTENTS

Unit I	**Introduction**	**9 Hrs.**	**CO1**

Control system - Basic components - Open and closed Loop - Effect of feedback - System representations - Transfer functions of single input & single output and multivariable systems – Block diagrams – Signal flow graphs – Gain formula – Modeling of control components – Mechanical and electrical systems

Unit II	**Transfer Function Model and Analysis**	**9 Hrs.**	**CO1, CO2, CO3**

Standard test signals- steady state error and error constants - Time response – Damping ratio - Natural frequency – Effects of adding poles and zeros – Dominant poles - Stability – Routh Hurwitz criterion – Root locus, Angle and Magnitude Condition

Unit III	**Frequency-domain techniques**	**9 Hrs.**	**CO1,CO2**

Introduction, Frequency response specifications, Magnitude and phase plots of typical systems – Gain margin – Phase margin - Bode plot - Polar Plot, Nyquist stability criterion (Theoretical treatment only)

Unit IV	**Introduction to Compensators and Controllers**	**9 Hrs.**	**CO1, CO2, CO3, CO5**

Basic concept of P, PI and PID controllers, Working principle and transfer function of the Lag network, lead network, potentiometer, DC servo motors, and determine parameters of the PID controller using root locus.

Unit V	**State-space Introduction**	**9 Hrs.**	**CO1,CO2, CO4, CO5**

State space terminologies, State-space representations, Diagonalization, Eigenvalues and Stability, State Space to Transfer Function and Vice Versa, Concept of Controllability and Observability

Text Books

1. Nise N.S. "Control Systems Engineering", John Wiley & Sons, Incorporated, 2011
2. I.J. Nagrath, M. Gopal, "Control System Engineering", New Age International Publishers,6th edition, 2017

ReferenceBooks

1. Richard C Dorf and Robert H Bishop, "Modern Control Systems", Pearson Education, 12th Edition, 2011.
2. Katsuhiko Ogata, "Modern control system engineering", Prentice Hall, 2010.

Sr. No.	Components for Continuous Comprehensive Evaluation	Marks Allotted
1	Assignment 1 (Based on Units I and II) (Deadline: before Insem)	5
2	Assignment 2 (Based on Units III and IV) (Deadline: before Endsem)	5
3	LMS Tests (Best 5 out of a minimum of 10)	5
4	Class Test (Before End Sem on Units III, IV, V)	5

T.Y. B.Tech.
Pattern:2023 Semester: V (Electrical Engineering)
2306302:Synchronous and Special Purpose Machines

Teaching Scheme:	Credit Scheme:	Examination Scheme:
Theory: 3 Hrs./Week	**TH:3**	**Continuous Comprehensive Evaluation: 20Marks** **InSem Exam:20 Marks** **EndSem Exam: 60Marks**

Prerequisite Courses: Measurement and Instrumentation, Transformers and Induction Machines

Course Objectives: The objectives of the course are to
1. Explain the construction and working principle of three-phase synchronous machines and special-purpose motors.
2. Enable students to calculate the voltage regulation of the Alternator by different methods.
3. Study the applications of different machines in industrial, commercial and social sectors.

Course Outcomes: On completion of the course, students will be able to–

Course Outcomes		Bloom's Level
CO1	Understand the construction and working principle of three-phase Synchronous Machines and special-purpose motors.	1-Remember 2-Understand
CO2	Draw and explain the characteristics of three-phase Synchronous Machines and special-purpose motors.	2-Understand
CO3	Select appropriate machines for applications in Power Systems, the industrial sector, household and other Engineering applications.	3-Apply
CO4	Explain testing methods to evaluate the performance of machines through numerical.	4-Analyze

COURSE CONTENTS

Unit I	Three-phase Synchronous Machines	9hrs	CO1, CO2, CO3

Construction, rotating-field type and rotating type and their comparison. Excitation Methods.

Three-phase Synchronous Generator (Cylindrical rotor type):
Principle of operation. EMF equation and winding factors (No derivation), rating of the generator. Generator on no-load and on balanced load. Armature reaction and its effect under different load power factors. Voltage drops due to armature resistance, leakage flux and synchronous reactance, per phase equivalent circuit, Power - power angle relation.

Three-phase Synchronous Generator (Salient pole type):
Armature reaction as per Blondel's two reaction theory for salient-pole machines, Direct-axis and quadrature-axis synchronous reactance and their determination by the slip test. Phasor diagram of the salient-pole generator and calculation of voltage regulation.

Unit II	Voltage Regulation and Parallel Operation of 3-phase Alternator	9 hrs	CO2, CO4

Voltage Regulation of Three-phase Synchronous Generator:
Performance of open circuit and short circuit test on the synchronous generator, determination of voltage regulation by EMF, MMF, and Potier triangle methods. Determination of voltage regulation by direct loading. Short circuit ratio.

Parallel Operation of 3-phase Alternators:
Necessity, conditions, and Load sharing between two alternators in parallel (Descriptive treatment only). Process of synchronizing the alternator with the infinite bus-bar by lamp methods and by use of a synchroscope (one dark & two equally bright methods). Synchronizing current, power and torque (no

numerical).

Unit III	**Three-phase Synchronous Motor**	**9 hrs**	**CO1, CO2, CO3**

Principle of operation, Methods of starting. Equivalent circuit, significance of torque angle, Losses, efficiency and Power flow chart. Operation of a 3-phase Synchronous motor with constant load and variable excitation (‘V’ Curves and ‘inverted V’ curves). The phenomenon of hunting and its remedies. Applications of 3-phase synchronous motors. Comparison of 3-phase synchronous motor with 3-phase induction motor. Damper Windings. Numericals on power input, power factor, and torque.

Unit IV	**A.C. Series Motor**	**9 hrs**	**CO2**

Operation of D.C. series motor on a.c. Supply, nature of torque developed, and problems associated with AC. Operation and remedies. Compensated series motor: Compensating winding, conductively and inductively compensated motor. Approximate phasor diagram. Use of compoles for improving communication. Ratings and applications of Compensated Series motors. Universal motors: Ratings, performance and applications, comparison of their performance on A.C. and D.C. supply.

Unit V	**Special Purpose Motors**	**9 hrs**	**CO1, CO2, CO3**

Construction, principle of working, characteristics, ratings and applications of Brushless D.C. motors, Stepper motors (permanent magnet and variable reluctance type only), Permanent Magnet motor (A.C. & D.C.). PMSM Motor, AC servomotors, Synchronous Reluctance Motors**.**

Text Books

1. P. S. Bimbhra, Electric Machinery, Khanna Publications
2. J. Nagrath, D. P. Kothari, “Electrical Machines” (4^{th} Edition), Tata McGraw-Hill. Publishing Co. Ltd., 2010.
3. V. K. Mehta and Rohit Mehta, Principles of Electrical Machines, S. Chand Publication
4. B. L Theraja –Electrical Technology, Vol. II, S. Chand Publication.
5. A.E. Fitzgerald, Charles Kingsley Jr., Stephen D. Umans, “Electric Machinery”, Tata McGraw Hill Publication, sixth edition, 2002.

Reference Books

1. M.G. Say, Performance and Design of A.C. Machines (3rd Ed.), ELBS
2. P.C. Sen, “Principles of Electric Machines and Power Electronics”, John Wiley and Sons Publication, second edition, 1997
3. J B Gupta - Theory and performance of Electrical Machines, S K Kataria Publication
4. E.G. Janardanan, Special Electrical Machines, Prentice Hall of India

Guidelines for Continuous Comprehensive Evaluation of Theory Course

Sr. No.	Components for Continuous Comprehensive Evaluation	Marks Allotted
1	Assignment 1 (Based on Units I and II) (Deadline: before Insem)	5
2	Assignment 2 (Based on Units III and IV) (Deadline: before Endsem)	5
3	LMS Test (Best 5 out of a minimum of 10)	5
4	Class Test (Before Endsem on Units III, IV, V)	5

T.Y. B.Tech.
Pattern:2023 Semester: V (Electrical Engineering)
2306303: Power System Analysis

Teaching Scheme:	Credit Scheme:	Examination Scheme:
Theory: 3 Hrs./Week	**TH: 3**	**Continuous Comprehensive Evaluation: 20Marks** **InSem Exam: 20Marks** **EndSem Exam: 60Marks**

Prerequisite Courses: Power System Engineering

Course Objectives: The objectives of the course are to

1. Develop analytical skills to solve problems related to power systems.
2. Enable students to apply different algorithms and numerical techniques to power system analysis.
3. Develop critical thinking ability to solve problems in power systems.

Course Outcomes: On completion of the course, students will be able to–

	Course Outcomes	Bloom's Level
CO1	Classify and define types of faults, stabilities, and load flow methods	1-Remember
CO2	Calculate per-unit values and draw per unit impedance diagram of power system components.	3-Apply
CO3	Analyze power system faults and stability conditions.	4-Analyze
CO4	Evaluate load flow analysis and power system stability.	5-Evaluate

COURSE CONTENTS

Unit I	**Representation of Power System Components**	**08hrs**	**CO1, CO2**

Per unit system: Single line diagram, Impedance and reactance diagrams and their uses, per unit quantities, relationships, selection of base, change of base, reduction to common base, advantages and application of per unit system. Numericals on network reduction by using the per unit system.

Unit II	**Load Flow Analysis**	**07hrs**	**CO1, CO4**

Network topology, driving point and transfer admittance, concept of Z-bus and formulation of Y-bus matrix using bus incidence matrix method, Numerical based on Y bus Matrix, power- flow equations generalization to n bus systems, classification of buses, Newton- Raphson method (polar method) Decoupled and Fast decoupled load flow (descriptive treatment only).

Unit III	**Symmetrical Fault Analysis**	**10hrs**	**CO1, CO2, CO3**

Introduction, transient on a transmission line, short circuit of a synchronous machine on no load, short circuit of a loaded synchronous machine, balanced three-phase fault, short circuit capacity, fault analysis using bus impedance matrix, selection of protective equipment.

Unit IV	**Unsymmetrical Fault Analysis**	**10hrs**	**CO1, CO2, CO3**

Symmetrical component analysis of unsymmetrical faults, single line to ground (LG) fault, line to line (LL) fault, double line to ground (LLG) fault, open conductor faults, bus impedance matrix method for analysis of unsymmetrical faults.

Unit V	**Power System Stability**	**10hrs**	**CO1, CO3, CO4**

Importance of stability analysis in power system planning and operation - classification of power system stability - angle and voltage stability – simple treatment of angle stability into small-signal and large-signal (transient) stability Single Machine Infinite Bus (SMIB) system: Development of swing equation - equal area criterion - determination of critical clearing angle and time.

Text Books

1. Hadi Saadat, Power System Analysis, 5th reprint, Tata McGraw-Hill Publishing Company Ltd, New Delhi, 2004. 3. I. J.
2. Nagrath and D. P. Kothari, Power System Engineering, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 3rd Edition, 2014.
3. Ashfaq Hussain, Electrical power system, fifth edition, CBS Publishers & Distributors Pvt Ltd.

Reference Books

1. J. J. Grainger and W. D. Stevenson, Power System Analysis, McGraw-Hill, New Delhi, 1st Edition, 1994.
2. Duncan Glover, S. Mulkutla Sarma and Thomas Overby, Power System Analysis and Design, 5th Edition, Cengage Learning, 2012.
3. Arthur R. Bergen, Vijay Vittal, Power Systems Analysis, Prentice Hall of India, Inc., 2nd Edition, 2000

NPTEL Course:

1. Dr. Debpriya Das, "Power System Analysis" https://onlinecourses.nptel.ac.in/noc19_ee62/preview

Guidelines for Continuous Comprehensive Evaluation of Theory Course

Sr. No.	Components for Continuous Comprehensive Evaluation	Marks Allotted
1	Assignment 1 (Based on Units I and II) (Deadline: before Insem)	5
2	Assignment 2 (Based on Units III and IV) (Deadline: before Endsem)	5
3.	LMS Test (Best 5 out of a Minimum of 10)	5
4.	Class Test (Before End Sem on Units III, IV, V) OR Test on GATE questions	5

T.Y. B.Tech.
Pattern:2023 Semester: V (Electrical Engineering)
2306304:Control System Engineering Lab

Teaching Scheme:	Credit Scheme:	Examination Scheme:
Practical:2 Hrs./Week	PR:2	Term Work:25Marks Oral:25 Mark

Prerequisite Courses: Advanced Calculus and Transform Techniques, Electrical Network Analysis

Course Objectives: The objectives of the course are to

1. Introduce the fundamental concepts of control systems, including open-loop and closed-loop systems
2. Enable students to model and analyze physical systems using block diagrams and mathematical tools.
3. Provide hands-on experience with hardware kits and simulation tools like MATLAB for system analysis
4. Expose students to real-world industrial control applications through practical experiments and visits as individual activities or group activities.

Course Outcomes: On completion of the course, students will be able to–

	Course Outcomes	Bloom's Level
CO1	Classify and model different types of control systems and sketch their block diagrams	3- Apply
CO2	Demonstrate understanding of industrial control components like servomotors, synchros, and PID controllers	3- Apply
CO3	Analyze time and frequency responses of dynamic systems using both hardware and software tools in teams or as an individual	4 – Analyze
CO4	Determine transfer functions, assess system stability, and interpret Root Locus, Bode, and Nyquist plots using software.	4 – Analyze

List of Laboratory Experiments

Perform any 8 Experiments, four from 1 to 5 and four from 6 to 10. An industrial visit is compulsory.

Sr. No.	Laboratory Experiments	COs Mapped
1	Model and analyse a physical system with proper inputs, outputs, disturbances and sketch a block diagram with justification (closed loop, open loop, feedforward, tracking or regulating system)	CO1
2	Study of Speed-Torque Characteristics of DC Servomotor/ AC Servomotor	CO2
3	Obtain the step response of a second-order system using an RLC circuit and determine the time domain specifications and verification using simulation.	CO3
4	Study of Flow Control and Level Control Kit using PID	CO1, CO2, CO3
5	Study of Synchro Transmitter and Receiver System	CO3
6	Sketch the Root Locus for a given system using MATLAB and verify by calculation	CO4
7	Sketch a Bode Plot for a given system using MATLAB and verify by calculation	CO4
8	Sketch a Polar Plot/Nyquist Plot for a given system using MATLAB and verify by calculation	CO4
9	Determine of transfer function from the state model and vice versa of the	CO4

	system using MATLAB and verify by calculation	
10	Determine of controllability and observability of the system using MATLAB and verify by calculation	CO4
11	Industrial Visit to a Control System/Automation-Based Industry	CO1, CO2

Guidelines for Laboratory Conduction

1. The teacher will brief the given experiment to students for its procedure, observations, calculations, and outcome.
2. The apparatus and equipment required for the allotted experiment will be provided by the lab technician.
3. Students will perform the allotted experiment in a group (3-4 students in each group) under the supervision of faculty and a lab technician.
4. After performing the experiment, students will check their readings and calculations from the teacher.
5. After checking, they have to write the conclusion on the final results.
6. A minimum of 4 sets of the experiment should be made ready for the conduction of the experiment in a batch for hardware experiments.

Guidelines for Students' Lab Journal

The write-up should include a title, aim and apparatus, circuit or block diagram, waveforms, brief theory, procedure, observations, graphs, calculations, conclusion, and answers to the questions, if any.

Guidelines for Term Work Assessment

Each experiment from the lab journal is assessed for thirty marks based on three rubrics. Rubric R-1 for timely completion, R-2 for understanding, and R-3 for presentation/journal writing, where each rubric carries ten marks.

T.Y. B.Tech Pattern 2023: Semester: V(Electrical Engineering) 2306305: Machines and Power System Lab		
Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Practical: 2Hrs./Week	**PR: 1**	**Term Work: 25** **Practical: 25**

Prerequisite Courses: Power System Engineering, Transformer and Induction Machines.

Course Objectives: The objectives of the course are to
1. Introduce the components of a power system, including generators, transformers, transmission lines, and loads, and understand their interactions and behaviors.
2. Enable students to use various measurement instruments and techniques to measure electrical quantities such as voltage, current, power, and frequency.
3. Empower students to conduct tests on electrical machines to analyze their performance, determine efficiency, and obtain characteristics under different operating conditions.
4. Provide exposure to software tools for simulating and analyzing electrical machines and power systems, allowing for virtual experimentation and system analysis.

Course Outcomes: On completion of the course, students will be able to–

	Course Outcomes	**Bloom's Level**
CO1	Explain the construction, operation, and applications of synchronous and special machines.	2-Understand
CO2	Apply software tools to conduct power system analysis in a group or as an individual	3-Apply
CO3	Analyze test data to evaluate the performance parameters of machines in a group or as an individual	4-Analyze
CO4	Evaluate power system behavior using power flow and fault analysis in a group or as an individual.	5- Evaluate
CO5	Interpret experimental results and present findings in technical reports	5-Evaluate

List of Laboratory Experiments
1) Perform any FIVE experiments from Sr. No. 1 to 7
2) Perform any FOUR Experiments from Sr. 8 to 12

*Industrial visit is compulsory, Sr. No. 13

Sr. No.	**Laboratory Experiments**	**COs Mapped**
1	Determine the voltage regulation of a cylindrical rotor alternator by a) EMF method and b) MMF method.	CO1, CO3, CO5
2	Determine of voltage regulation of the cylindrical rotor alternator by the Potier method.	CO1, CO3, CO5
3	Plot V and inverted V curves of the synchronous motor at constant load.	CO1, CO3, CO5
4	Perform a Load Test on the AC Series motor.	CO1, CO3, CO5
5	Perform speed control on the BLDC motor	CO1, CO3, CO5
6	Determine the sub-synchronous direct and quadrature axis reactance of a salient pole synchronous machine.	CO1, CO3, CO5
7	Determine the negative and zero sequence impedance of synchronous machines.	CO1, CO3, CO5
8	Study load frequency control using an approximate and exact model.	CO2, CO4,CO5

9	Study load frequency control with proportional and integral control.	CO2, CO4,CO5
10	Find the fault level and plot the related voltage and current waveforms of a given power system subjected to symmetrical faults with professional software. (ETAP/PSCAD)	CO2, CO4,CO5
11	Find the fault level and plot the related voltage and current waveforms of a given power system subjected to unsymmetrical faults with professional software. (ETAP/PSCAD)	CO2, CO4,CO5
12	Analyze the stability of the system using equal area criteria in the SIMB system for any one case from the following. a) Fault at the centre of one of the lines in parallel transmission. b) Change in mechanical input	CO2, CO4,CO5
13	Industrial visit to a synchronous or special-purpose machines manufacturing unit /Power Station Control Room.	CO5

Guidelines for Laboratory Conduction

1. The teacher will brief the given experiment to students for its procedure, observations, calculations, and outcome.
2. The apparatus and equipment required for the allotted experiment will be provided by the lab technician.
3. Students will perform the allotted experiment in a group (3-4 students in each group) under the supervision of faculty and a lab technician.
4. After performing the experiment, students will check their readings and calculations from the teacher.
5. After checking, they have to write the conclusion on the final results.
6. A minimum of 2 sets of the experiment should be made ready for the conduction of the experiment in a batch for hardware experiments.

Guidelines for Student's Lab Journal

The write-up should include a title, aim and apparatus, circuit or block diagram, waveforms, brief theory, procedure, observations, graphs, calculations, conclusion, and answers to the questions, if any.

Guidelines for Term Work Assessment

Each experiment from the lab journal is assessed for thirty marks based on three rubrics. Rubric R-1 for timely completion, R-2 for understanding, and R-3 for presentation/journal writing, where each rubric carries ten marks.

T.Y. B.Tech. Pattern: 2023 Semester: V (Electrical Engineering) 2306306A: High Voltage Engineering		
Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Theory: 3 Hrs./Week	**TH-3**	**Continuous Comprehensive Evaluation: 20 Marks** **In Sem Exam: 20 Marks** **End Sem Exam: 60 Marks**

Prerequisite Courses: Power System Engineering, Measurement and Machine.

Course Objectives: The objectives of the course are to

1. Enable students to know and compare the physical high voltage phenomena and its impact in solid, liquid and gaseous dielectric materials
2. Enable students to understand and apply various methods of generation and measurement of DC, AC, impulse voltage and current.
3. Enable students to know the charge formation and separation phenomenon in clouds, the causes of over-voltage and the lightning phenomenon.
4. Develop the ability among students to test various high-voltage equipment as per standards

Course Outcomes: On completion of the course, students will be able to—

	Course Outcomes	**Bloom's Level**
CO1	Explain the behavior of different dielectric materials under high voltage and current.	2-Understand
CO2	Select appropriate methods for producing high voltages and currents	2-Understand
CO3	Apply appropriate methods for measurement of high AC, DC, impulse voltage and current.	3-Apply
CO4	Analyse insulation coordination strategies and interpret high voltage testing procedures for insulators with safety protocols	4- Analyze

COURSE CONTENTS

Unit I	**Gaseous Dielectrics**	**9 hrs**	**CO1**

Ionization process in gas, Townsend's Theory, current growth equation in presence of primary and secondary ionization processes, Townsend's breakdown criterion, primary and secondary ionization coefficients, limitations of Townsend's theory, Streamer mechanism of breakdown, Paschen's Law and its limitations, Corona discharges for point plane electrode combination with positive and negative pulse application, time lag and factors on which time lag depends.

Unit II	**Liquid and Solid Dielectrics**	**9 hrs**	**CO1**

Breakdown in Liquid Dielectrics: Pure and commercial liquids, Different breakdown theories: Breakdown in Pure liquid and breakdown in commercial liquids: Suspended Particle theory, cavitation and bubble theory, Thermal mechanism of breakdown and Stressed Oil volume theory. **Breakdown in Solid Dielectrics:** Intrinsic breakdown: electronic breakdown, avalanche or streamer breakdown, Electro-mechanical breakdown, thermal breakdown, treeing and tracking phenomenon, Chemical and Electro-chemical breakdown, Partial discharge(Internal discharge), Composite dielectric material, Properties of composite dielectrics, breakdown in composite dielectrics.

Unit III	**Generation of High Voltages and Current**	**9 hrs**	**CO2**

Generation of high AC voltages- Cascading of transformers, series and parallel resonance systems, Tesla coil. Generation of impulse voltages and current-Impulse voltage definition, wave front and wave tail time, Multistage impulse generator, Modified Marx circuit, Tripping and control of impulse generators, Generation of high impulse current.

Unit IV	Measurement of High Voltage and High Current	9 hrs	CO3

Sphere gap voltmeter, electrostatic volt meter, generating voltmeter, peak reading voltmeter, resistive, capacitive and mixed potential divider, capacitance voltage transformer, cathode ray oscilloscope for impulse voltage and current measurement, measurement of dielectric constant and loss factor, partial discharge measurements. Measurement of high power frequency AC using a current transformer with an Electro-optical signal converter, Radio interference measurements.

Unit V	High Voltage Testing and Industrial Applications	9 hrs	CO4

Causes of over-voltages, lightning phenomenon, Different types of lightning strokes and mechanisms of lightning strokes, Charge separation theories, Wilson theory, Simpson theory, Reynolds and Mason theory, over-voltage due to switching surges and methods to minimise switching surges. Statistical approach to insulation coordination. Testing of insulators and bushings, Power capacitors and cables testing, testing of surge arresters. High voltage safety protocols, IEEE Standard on HV testing (IEEE 510, IEEE Std 4, and IEC 60060-1/2).

Text Books

1. M. S. Naidu, V. Kamaraju, "High Voltage Engineering", Tata McGraw- Hill Publication Co. Ltd., New Delhi
2. C. L. Wadhwa, "High Voltage Engineering", New Age International Publishers Ltd.

Reference Books

1. E. Kuffel, W. S. Zaengl, J. Kuffel, "High Voltage Engineering Fundamentals", Newnes Publication
2. Prof. D. V. Razevig Translated from Russian by Dr. M. P. Chourasia, "High Voltage Engineering", Khanna Publishers, New Delhi
3. Ravindra Arora, Wolf Gang Moseh, "High Voltage Insulation Engineering", New Age International
4. High Voltage Engineering Theory and Practice by M. Khalifa, Marcel Dekker Inc., New York and Basel.
5. Subir Ray, "An Introduction to High Voltage Engineering", PHI Pvt. Ltd., New Delhi
6. NPTEL lectures
7. IS 731- 1971: Porcelain insulator for overhead power lines with nominal voltage > 1000 volts
8. Bushings :IS2099-1986,specification for bushings for A.C. Voltages > 1000 Volts
9. Pollution test: IEC 60507-1991 on external and internal insulator
10. High voltage test techniques, general definitions and test requirements: IS 2071(part 1) 1993, IEC Pub 60-1(1989)

Sr. No.	Components for Continuous Comprehensive Evaluation	Marks Allotted
1	Assignment l (Based on Units I and II) (Deadline: before Insem)	5
2	Assignment 2 (Based on Units III and IV) (Deadline: before End sem)	5
3.	LMS Tests (Best 5 out of a minimum of 10)	5
4.	Class Test (Before End Sem on Units III, IV, V)	5

T.Y. B.Tech.
Pattern: 2023 Semester: V (Electrical Engineering)
2306306B: Electric Mobility

Teaching Scheme:	Credit Scheme:	Examination Scheme:
Theory: 3 Hrs./Week	TH: 3	Continuous Comprehensive Evaluation: 20 Marks InSem Exam: 20 Marks EndSem Exam: 60 Marks

Prerequisite Courses:- Fundamentals of Electrical Engineering, Transformers and Induction Machines, Power Electronics

Course Objectives: The objectives of the course are to
1. Introduce students to the fundamentals and components of electric mobility.
2. Explore power electronics, battery systems, and control systems in EVs.
3. Enable students to analyze state-of-the-art developments in EV infrastructure and smart mobility.
4. Develop an understanding of standards, policies, and future trends in e-mobility.

Course Outcomes: On completion of the course, students will be able to–

	Course Outcomes	Bloom's Level
CO1	**Explain** the architecture, classification, and operational principles of various electric vehicles and their key components.	2-Understand
CO2	**Select Motor,** electric drives and battery technologies suitable for different EV applications	3-Apply
CO3	**Analyse** current EV policies, charging technologies, and global trends to propose sustainable and smart mobility solutions	4-Analyze
CO4	Construct a basic electric vehicle drivetrain or battery pack considering performance, energy, and thermal constraints	5-Evaluate

COURSE CONTENTS

Unit I	Introduction to Electric Mobility and Vehicle Architecture:	9 hrs	CO1, CO3

Historical evolution and future of e-mobility, Comparison of EVs with ICE vehicles: performance, efficiency, emissions, Types of Electric Vehicles: BEV, HEV, PHEV, FCEV, Vehicle architecture: Series, Parallel, and Series-Parallel hybrids, Key components of EVs: traction motors, battery, BMS, inverters, chargers, Overview of Indian and global e-mobility scenarios

Unit II	Electric Drives and Motor Technologies for EVs	9 hrs	CO1, CO2, CO4

Requirements of traction motors, Motor types: BLDC, PMSM, Induction Motors, SRM – working, merits, selection, Torque-speed characteristics and drive cycle integration, Motor control techniques: V/f, vector control, direct torque control, Regenerative braking and energy recovery systems, Recent advances in motor technology for EVs

Unit III	Battery Technology and BMS	9 hrs	CO1, CO2, CO4

Fundamentals of batteries for EVs: Li-ion, LFP, NMC, solid-state batteries, Battery parameters: capacity, C-rate, SOC, SOH, energy density, Battery sizing and pack design, Thermal management in battery systems, Battery Management System (BMS): architecture, sensing, balancing, protection, Safety and second-life application, Ultracapacitor, Fuel Cells, Flywheel

Unit IV	Power Electronics and Charging Infrastructure	9 hrs	CO1, CO2, CO4, CO3

Power electronic converters in EVs: DC-DC, DC-AC, AC-DC, On-board vs off-board charging, EV

charging standards: CHAdeMO, CCS, GB/T, Bharat EV protocols, Charging infrastructure: Levels of charging, AC/DC fast charging, Wireless and bidirectional charging (V2G, V2H), Smart grid integration and demand response			
Unit V	**EV Policies and Trends**	**9 hrs**	**CO3**
National Electric Mobility Mission Plan (NEMMP), FAME I and II policies, state EV policies, Environmental and socio-economic impacts, Autonomous electric vehicles, connected EVs, Role of AI/ML in route optimization and battery analytics, EV startups, innovation, and entrepreneurship, Global collaboration and standardization, IEEE P2030.1.1/D2, IEEE P2030.1.1/D4			
Text Books			
1. Iqbal Hussain, "Electric & Hybrid Vehicles – Design Fundamentals", Second Edition, CRC Press, 2011. 2. James Larminie, "Electric Vehicle Technology Explained", John Wiley & Sons, 2003.			
Reference Books			
1. Mehrdad Ehsani, Yimin Gao, Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals", CRC Press, 2010. 2. Tom Denton, "Automobile Electrical and Electronic Systems", SAE International publications. 3. Junwei Lu & Jahangir Hossain, "Vehicle-to-Grid: Linking Electric Vehicles to the Smart Grid" et al (eds), IET Digital Library.			

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	Assignment 1 (Based on Units I and II) (Deadline: before Insem)	5
2	Assignment 2 (Based on Units III and IV) (Deadline: before Endsem)	5
3	LMS Tests (Best 5 out of a minimum of 10)	5
4	Class Test (Before Endsem on Units III, IV, V)	5

T.Y. B.Tech.
Pattern: 2023 Semester: V (Electrical Engineering)
2306306B: Electric Mobility

Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Theory: 3 Hrs./Week	**TH: 3**	**Continuous Comprehensive Evaluation: 20 Marks** **InSem Exam: 20 Marks** **EndSem Exam: 60 Marks**

Prerequisite Courses:- Fundamentals of Electrical Engineering, Transformers and Induction Machines, Power Electronics

Course Objectives: The objectives of the course are to
1. Introduce students to the fundamentals and components of electric mobility.
2. Explore power electronics, battery systems, and control systems in EVs.
3. Enable students to analyze state-of-the-art developments in EV infrastructure and smart mobility.
4. Develop an understanding of standards, policies, and future trends in e-mobility.

Course Outcomes: On completion of the course, students will be able to–

	Course Outcomes	**Bloom's Level**
CO1	**Explain** the architecture, classification, and operational principles of various electric vehicles and their key components.	2-Understand
CO2	**Select Motor,** electric drives and battery technologies suitable for different EV applications	3-Apply
CO3	**Analyse** current EV policies, charging technologies, and global trends to propose sustainable and smart mobility solutions	4-Analyze
CO4	Construct a basic electric vehicle drivetrain or battery pack considering performance, energy, and thermal constraints	5-Evaluate

COURSE CONTENTS

Unit I	**Introduction to Electric Mobility and Vehicle Architecture:**	**9 hrs**	**CO1, CO3**

Historical evolution and future of e-mobility, Comparison of EVs with ICE vehicles: performance, efficiency, emissions, Types of Electric Vehicles: BEV, HEV, PHEV, FCEV, Vehicle architecture: Series, Parallel, and Series-Parallel hybrids, Key components of EVs: traction motors, battery, BMS, inverters, chargers, Overview of Indian and global e-mobility scenarios

Unit II	**Electric Drives and Motor Technologies for EVs**	**9 hrs**	**CO1, CO2, CO4**

Requirements of traction motors, Motor types: BLDC, PMSM, Induction Motors, SRM – working, merits, selection, Torque-speed characteristics and drive cycle integration, Motor control techniques: V/f, vector control, direct torque control, Regenerative braking and energy recovery systems, Recent advances in motor technology for EVs

Unit III	**Battery Technology and BMS**	**9 hrs**	**CO1, CO2, CO4**

Fundamentals of batteries for EVs: Li-ion, LFP, NMC, solid-state batteries, Battery parameters: capacity, C-rate, SOC, SOH, energy density, Battery sizing and pack design, Thermal management in battery systems, Battery Management System (BMS): architecture, sensing, balancing, protection, Safety and second-life application, Ultracapacitor, Fuel Cells, Flywheel

Unit IV	**Power Electronics and Charging Infrastructure**	**9 hrs**	**CO1, CO2, CO4, CO3**

Power electronic converters in EVs: DC-DC, DC-AC, AC-DC, On-board vs off-board charging, EV charging standards: CHAdeMO, CCS, GB/T, Bharat EV protocols, Charging infrastructure: Levels of charging, AC/DC fast charging, Wireless and bidirectional charging (V2G, V2H), Smart grid integration

and demand response			
Unit V	**EV Policies and Trends**	**9 hrs**	**CO3**
National Electric Mobility Mission Plan (NEMMP), FAME I and II policies, state EV policies, Environmental and socio-economic impacts, Autonomous electric vehicles, connected EVs, Role of AI/ML in route optimization and battery analytics, EV startups, innovation, and entrepreneurship, Global collaboration and standardization, IEEE P2030.1.1/D2, IEEE P2030.1.1/D4			
Text Books			
1. Iqbal Hussain, "Electric & Hybrid Vehicles – Design Fundamentals", Second Edition, CRC Press, 2011. 2. James Larminie, "Electric Vehicle Technology Explained", John Wiley & Sons, 2003.			
Reference Books			
1. Mehrdad Ehsani, Yimin Gao, Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals", CRC Press, 2010. 2. Tom Denton, "Automobile Electrical and Electronic Systems", SAE International publications. 3. Junwei Lu & Jahangir Hossain, "Vehicle-to-Grid: Linking Electric Vehicles to the Smart Grid" et al (eds), IET Digital Library.			

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	Assignment 1 (Based on Units I and II) (Deadline: before Insem)	5
2	Assignment 2 (Based on Units III and IV) (Deadline: before Endsem)	5
3	LMS Tests (Best 5 out of a minimum of 10)	5
4	Class Test (Before Endsem on Units III, IV, V)	5

T.Y. B.Tech. Pattern: 2023 Semester: V (Electrical Engineering) 2306307A: High Voltage Engineering Lab		
Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Practical: 2 Hrs./Week	**PR: 1**	**Term Work: 25 Oral: 25**

Prerequisite Courses: Power System Engineering, Fundamentals of Electrical Engineering

Course Objectives: The objectives of the course are to

1. Explain the causes and mitigation of overvoltages in power systems.
2. Explore dielectric properties and breakdown mechanisms.
3. Demonstrate methods of generating and measuring high voltages and currents.
4. Familiarize students with high voltage testing techniques and international standards.

Course Outcomes: On completion of the course, students will be able to–

	Course Outcomes	**Bloom's Level**
CO1	Understand and measure breakdown and high voltage phenomena in air and across measurement setups in groups of 4-5 students	3-Apply
CO2	Analyze and perform impulse voltage generation and testing procedures in groups of 4-5 students	4-Analyze
CO3	Evaluate insulation properties and detect partial discharges in high-voltage systems in groups of 4-5 students	3-Apply, 4-Analyze
CO4	Simulate and validate electric field distribution and perform standard-compliant testing	3-Apply, 4-Analyze

List of Laboratory Experiments

At least 8 experiments are to be performed out of the following list:

Sr. No.	**Laboratory Experiments**	**COs Mapped**
1	Measurement of breakdown voltage of air using sphere gap.	CO1
2	Study of impulse voltage generation using the Marx generator.	CO2
3	Measurement of high voltage using a capacitive/resistive divider.	CO1
4	Simulation of electric field using software tools (e.g., FEMM/COMSOL/Ansys).	CO4
5	Impulse testing of transformer winding model.	CO2
6	Measurement of dielectric strength of insulating oil.	CO3
7	Study of partial discharge using PD detection kit.	CO3
8	Measurement of surface and volume resistivity of solid insulation.	CO3
9	Measurement of leakage current and insulation resistance using a megger.	CO3
10	High voltage testing of insulators/cables as per standards.	CO4
11	Simulation and analysis of overvoltage protection using surge arresters	CO2
12	Study and testing of corona discharge phenomenon on transmission line models	CO4
13	Determination of flashover voltage using a rod-rod or rod-plane gap	CO1
14	Analysis of breakdown characteristics of solid insulation under AC/DC voltages	CO3
15	Study of grounding system resistance using fall-of-potential method	CO1

16	Measurement of capacitance and dissipation factor (tan δ) of insulation using Schering Bridge	CO3
17	Simulation of lightning impulse and switching impulse effects on power systems using software tools	CO4
18	Study and testing of insulation coordination in high voltage systems using simulation tools	CO4

Guidelines for Laboratory Conduction

1. The teacher will brief the given experiment to students for its procedure, observations, calculations, and outcome.
2. The apparatus and equipment required for the allotted experiment will be provided by the lab technician.
3. Students will perform the allotted experiment in a group (3-4 students in each group) under the supervision of faculty and a lab technician.
4. After performing the experiment, students will check their readings and calculations from the teacher.
5. After checking, they have to write the conclusion on the final results.
6. A minimum of 4 sets of the experiment should be made ready for the conduction of the experiment in a batch for hardware experiments.

Guidelines for Student's Lab Journal

The write-up should include a title, aim and apparatus, circuit or block diagram, waveforms, brief theory, procedure, observations, graphs, calculations, conclusion, and answers to the questions, if any.

Guidelines for Term Work Assessment

Each experiment from the lab journal is assessed for thirty marks based on three rubrics. Rubric R-1 for timely completion, R-2 for understanding, and R-3 for presentation/journal writing, where each rubric carries ten marks.

T.Y. B.Tech.
Pattern: 2023 Semester: V (Electrical Engineering)
2306307B: Electric Mobility Lab

Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Practical: 2 Hrs./Week	**PR:1**	**Term Work:25 Marks** **Oral: 25 Mark**

Prerequisite Courses: Fundamentals of Electrical Engineering, Transformers and Induction Machines, Power Electronics

Course Objectives: The objectives of the course are to

1. Develop hands-on skills in simulating and analyzing electric vehicle components such as motors, batteries, and power converters.
2. Enable students to design and evaluate electric vehicle subsystems using appropriate software and hardware tools.
3. Expose students to real-world drive cycles and performance metrics for electric mobility applications.
4. Foster an understanding of control strategies, battery management, and energy efficiency in EV systems.

Course Outcomes: On completion of the course, students will be able to–

	Course Outcomes	**Bloom's Level**
CO1	**Simulate and interpret performance characteristics** of electric motors and powertrains used in EVs	4- Analyze
CO2	**Analyze energy consumption, range estimation, and efficiency** under different drive conditions	4-Analyze
CO3	**Design battery packs and power electronics circuits** for EV applications in a group of 4-5 members	6-Create

List of Laboratory Experiments

Sr. No.	**Laboratory Experiments**	**COs Mapped**
1	Study of 2-Wheeler Electric Vehicle Harness and Powertrain	CO1, CO2
2	Study and Testing of EV Machine & Drives **(**BLDC Hub, BLDC Mid, PMSM, SRM Motor, Induction Motor)	CO1, CO2
3	Study and Testing of EV Machine & Drives **(**PMSM, SRM Motor, Induction Motor)	CO1, CO2
4	Study of EV Wiring Harness, IOT & Telematics	CO2
5	Group Simulation of EV using MATLAB and analysis of the behavior	CO1, CO2
6	Group Design of Arduino-Based Battery Monitoring System for EV	CO1, CO2, CO3
7	Group study of a research paper on EV technology	CO1, CO2, CO3
8	Visit to the Industry / Charging Infrastructure of Electric Vehicles	CO1, CO2, CO3

Guidelines for Laboratory Conduction
1. The teacher will brief the given experiment to students for its procedure, observations, calculations, and outcome. 2. The apparatus and equipment required for the allotted experiment will be provided by the lab technician. 3. Students will perform the allotted experiment in a group (3-4 students in each group) under the supervision of faculty and a lab technician. 4. After performing the experiment, students will check their readings and calculations from the teacher. 5. After checking, they have to write the conclusion on the final results. 6. A minimum of 4 sets of the experiment should be made ready for the conduction of the experiment in a batch for hardware experiments.
Guidelines for Student's Lab Journal
The write-up should include a title, aim and apparatus, circuit or block diagram, waveforms, brief theory, procedure, observations, graphs, calculations, conclusion, and answers to the questions, if any.
Guidelines for Term Work Assessment
Each experiment from the lab journal is assessed for thirty marks based on three rubrics. Rubric R-1 for timely completion, R-2 for understanding, and R-3 for presentation/journal writing, where each rubric carries ten marks.

T. Y. B. Tech. **Pattern: 2023Semester: V (Electrical Engineering)** **2306308: Massive Open Online Course**		
Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Theory: 2 Hrs./Week	**TH-2**	**Continuous Comprehensive Evaluation: 50 Marks**
Prerequisite Courses: NA		
Course Content		
Students have to select the MOOC from the list declared by the department.		

Course Code	Course Type	Title of Course
2306308A	OE	Economic Environment and Business Strategy https://onlinecourses.nptel.ac.in/noc25_ec16/preview
2306308B		Energy Economics and Policy https://onlinecourses.nptel.ac.in/noc25_hs136/preview
2306308C		Corporate Finance https://onlinecourses.nptel.ac.in/noc25_mg138/preview
2306308D		The Psychology of Language https://onlinecourses.nptel.ac.in/noc25_hs193/preview
2306308E		Introduction to Exercise Physiology & Sports Performance https://onlinecourses.nptel.ac.in/noc25_hs156/preview
2306308F		Decision Modeling https://onlinecourses.nptel.ac.in/noc25_mg150/preview

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	Grading of the online course will be taken as it is and will be rounded to 50 marks.	50

Note: CO-PO-PSO Mapping will be decided after selecting the course and will be included in the Course Handout. The list of available courses is as follows.

T.Y. B.Tech. Pattern:2023 Semester: V (Electrical Engineering) 2306309: Digital Signal Processing		
Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Theory: 3 Hrs./Week	**TH-3**	**Continuous Comprehensive Evaluation: 20Marks InSem Exam: 20Marks EndSem Exam: 60Marks**

Prerequisite Courses: Advanced Calculus and Transform Techniques

Course Objectives: The objectives of the course are to

1. Introduce discrete signals and systems.
2. Enable students to analyze DT signals with Z transform, DTFT and DFT.
3. Introduce Digital filters and analyze the response.
4. Explore DSP Applications in Electrical Engineering.

Course Outcomes: On completion of the course, students will be able to–

	Course Outcomes	**Bloom's Level**
CO1	State and prove the properties of different transforms	2-Understand
CO2	Classify and perform mathematical operations on the discrete-time signal and system with its Z-transform	3-Apply
CO3	Construct and analyse the frequency response of the LTI system using Fourier Transform.	4-Analyze
CO4	Design and realize IIR and FIR filters.	6-Create

COURSECONTENTS

Unit I	**Discrete-Time System and Z-Transform**	**10 hrs**	**CO1, CO2**

Analog, Discrete-time and Digital signals, Basic sequences and sequence operations, Discrete-time systems, Properties of D. T. Systems and Classification, Linear Time Invariant Systems, impulse response, linear convolution and its properties, properties of LTI systems: stability, causality, Periodic Sampling, Sampling Theorem, Frequency Domain representation of sampling, reconstruction of a band- limited Signal, A to D Conversion Process: Sampling, quantization and encoding.

Unit II	**Discrete-Time Fourier Transform**	**8hrs**	**CO1, CO3**

Revision of Z-transform, Numerical of Z transform, Inverse Z transforms using partial fraction and power series method, Linear constant coefficient difference equations, solution of difference equation, stability and causality using ROC of Z-transform.
Representation of Sequences by the Fourier Transform, Symmetry properties of D.T., F.T. theorems: Linearity, time shifting, frequency shifting, time reversal, differentiation, convolution theorem, Frequency response analysis of first and second order systems, steady state and transient response.

Unit III	**Discrete Fourier Transform**	**8hrs**	**CO1, CO3**

Sampling in the frequency domain, The Discrete Fourier Transform, Relation with z- transform, Properties of DFT: Linearity, circular shift, duality, symmetry, Circular Convolution, Linear Convolution using DFT, Effective computation of DFT and FFT, DITFFT, DIFFFT.

Unit IV	**IIR Filter Design**	**10 hrs**	**CO4**

Ideal frequency selective filters, Concept of filtering, specifications of filter, IIR filter design from continuous time filters: Characteristics of Butterworth and Chebyshev, impulse invariant and bilinear transformation techniques, Design examples (Butterworth low pass filter), Basic structures for IIR Systems: direct form, cascade form

Unit V	**FIR Filter Design**	**9hrs**	**CO4**
Specifications of properties of commonly used windows, Design Examples using a rectangular window. Basic Structures for FIR Systems: Direct Form. Comparison of IIR and FIR Filters.			

Text Books

1. P. Ramesh Babu, "Digital Signal Processing",4th Edition, Sci Tech Publication.
2. Mitra S., "Digital Signal Processing: A Computer–Based Approach", Tata McGraw-Hill,1998, ISBN 0-07-044705-5

Reference Books

1. Proakis J., Manolakis D., "Digital signal processing", 3rd Edition, Prentice Hall, ISBN81-203-0720-8.
2. W.Rebizant, J.Szafran, A.Wiszniewski, "Digital Signal Processing in Power System Protection and Control", Springer 2011, ISBN 978-0-85729-801-0

NPTELCourse:

1. Dr.V.M.Gadre,"Digital Signal Processing and Its Applications" https://nptel.ac.in/courses/108101174

Guidelines for Continuous Comprehensive Evaluation of Theory Course

Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	Assignment 1 (Based on Units I and II) (Deadline: before Insem)	5
2	Assignment 2 (Based on Units III and IV)(Deadline: before Endsem)	5
3.	LMS Test (Best 5 out of a Minimum of 10)	5
4.	Programming Assignments	5

T.Y. B.Tech Pattern: 2023Semester: V (Electrical Engineering) 2306310:Education and Energy Awareness Program		
Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Tutorial: 1Hr./Week **Practical:2Hrs./Week**	**TU-1** **PR-1**	**Termwork:25Marks** **Tutorial: 25 Marks**

Prerequisite Courses: Fundamentals of Electrical Engineering, Power Generation Technologies, Environmental Science and Sustainable Development, Technical Communication and Report Writing.

Course Objectives: The objectives of the course are to

1. Develop technological literacy in sustainable and renewable energy.
2. Promote ethical considerations and global perspectives on energy challenges.
3. Equip students with communication skills for advocating sustainable practices.
4. Evaluate the social and environmental impact of energy-related interventions.

Course Outcomes: After successful completion of the course, students should be able to

CO	Course Outcomes	Bloom's Level
CO1	Select appropriate strategies to promote sustainable and efficient energy, safety practices and literacy in society	2-Understand
CO2	Function effectively as an individual, and as a member or leader to Give or receive clear instructions to the team for helping society.	3-Apply
CO3	Communicate effectively as an individual or a team, write reports, design documentation and give effective presentations.	5-Evaluate

Guidelines for Tutorial

The tutorial consists of the pre-preparation of experiments. Students have to select innovative ideas for demonstrating experiments, prepare a Demo/PPT/Poster for each practical and after completion of the experiment, write a detailed report on the activity/experiment completed.

Guidelines for Tutorial Assessment

Each tutorial will carry 25 marks based on
1. Demo/Poster/PPT for 10 marks
2. Innovative IdeaduringPreparationfor10Marks
3. ReportWriting-5Marks

The tutorial will also include the expert sessions by the social workers, social technology creators and innovators, etc. The attendance for these sessions will also be part of the tutorial. Suggested topics are

1. Basics of Energy Auditing and Conservation Techniques for Residential Homes
2. Understanding Renewable Energy Technologies for Rural Communities
3. How to Read and Explain an Electricity Bill
4. Low-Cost Smart Solutions for Energy Saving
5. Role of Engineers in Nation Building
6. Energy Access and the Rural-Urban Divide
7. Ethics and Values in Public Engagement
8. Inspiring Change: Journey of a Social Worker in Rural Development
9. Climate Change and the Common Man
10. Inclusive Communication: Working with Diverse Communities
11. Women and Energy: Empowerment Through Technology

List of Laboratory Experiments (Perform any 4 of the following)

Activity	Experiments Title	COs Mapped
1	Creating awareness on Electrical Energy Conservation Methods and Electrical Safety Practices in Rural Schools	CO1,CO2,CO3
2	Creating Awareness about Solar-Powered Water Pumping Systems for Sustainable Agricultural Applications to Farmers.	CO1,CO2,CO3
3	Creating Awareness about Modern Solar Technologies for Residential Buildings. (*e.g. adoption of advanced solar applications such as solar water heaters, solar lighting, smart bins, and solar mobile chargers etc.*)	CO1,CO2,CO3
4	Creating Digital Literacy and Basic Computer Education Awareness for Rural School Students.	CO1,CO2,CO3
5	Electricity Bill Literacy Workshop in Residential Buildings	CO1,CO2,CO3
6	Case Study on Solar PV Plants or Rooftop Solar Systems Integrated with Net Metering Mechanism and Awareness Creation in Rural Areas.	CO1,CO2,CO3

Guidelines for Laboratory Conduction

- A group of 10 students will be assigned to a faculty member, called a mentor.
- The mentor has the conduct of activities and plans the work schedule.
- A weekly review of the completed task should be taken, and further guidelines should be given to the group.
- After each activity, students have to present the work completed, prepare a video of the report.
- Use of technology in meaningful ways to help them investigate, collaborate, analyze, synthesize, and present their learning.

Guidelines for Term Work Assessment

Each activity will carry thirty marks based on their report writing and feedback analysis of external stakeholders. Rubric R-1 for timely completion, R-2 for understanding, and R-3 for presentation/journal writing, where each rubric carries ten marks.

T.Y. B.Tech.
Pattern:2023 Semester: VI (Electrical Engineering)
2306311: Computer-Aided Machine Design

Teaching Scheme:	Credit Scheme:	Examination Scheme:
Theory: 3 Hrs./Week	**TH:3**	**Continuous Comprehensive Evaluation: 20 Marks** **In-Sem Exam: 20 Marks** **End-Sem Exam: 60 Marks**

Prerequisite Courses: Transformer and Induction Machines, Synchronous and Special Purpose Machines

Course Objectives: The objectives of the course are to

1. Enable students to determine the performance parameters of the transformer and then design it.
2. Empower students to calculate the performance parameters of Induction motors and then design it.

Course Outcomes: On completion of the course, students will be able to–

	Course Outcomes	Bloom's Level
CO1	Explain transformer and induction motor specifications from the design point of view.	2-Understand
CO2	Apply engineering fundamentals for the design of the transformer and induction motor.	3-Apply
CO3	Determine performance based on the parameters of the transformer and induction motor.	4-Analyze
CO4	Evaluate transformer and induction motor performance using computer-aided design techniques	5-Evaluate

COURSE CONTENTS

Unit	Title	Hours	COs
Unit I	**Transformer Design: Part-I**	**09 hrs**	**CO1**
Modes of heat dissipation. Heating and cooling curves. Methods of cooling of the transformer. Types and constructional features of the core and windings used in a transformer. Transformer auxiliaries such as tap changer, pressure release valve, breather and conservator. Specifications of three-phase transformers as per IS 2026 (Part I). Introduction to computer-aided design.			
Unit II	**Transformer Design: Part II**	**09 hrs**	**CO1, CO2, CO3**
Transformer core constructions, windings, insulating oil and materials, various parts of transformers, Output equation, the equation for voltage per turn, optimum design of transformer for minimum cost and loss. Design of core, estimation of overall dimensions of frame and windings of transformer. Design of a tank with cooling tubes.			
Unit III	**Transformer Performance Evaluation**	**09 hrs**	**CO1, CO2, CO3, CO4**
Estimation of resistance and leakage reactance of the transformer. Estimation of no-load current, losses, efficiency and regulation of transformer. Calculation of mechanical forces developed under short-circuit conditions measures to overcome this effect. Computer-aided design of the transformer: a generalised flow chart for the design of the transformer.			
Unit IV	**Three-phase Induction Motor Design: Part-1**	**09 hrs**	**CO1, CO2, CO3**
Specifications and constructional features. Types of AC windings. Specific loadings, Output			

equation with usual notations. Calculations for main dimensions, turns per phase and the number of stator slots. Estimation of axial lengths, air gap diameter, slot dimension for stator and rotor, cage rotor and wound rotor design.

Unit V	Three-phase Induction Motor Design: Part II	09 hrs	CO1, CO2, CO3, CO4

Calculation of no-load current, Leakage flux and leakage reactance: Slot, tooth top, zig-zag, overhang. Leakage reactance calculation for three-phase machines. MMF Calculation for the air gap, stator teeth, stator core, rotor teeth and rotor core. Effect of saturation, effects of ducts on calculations of magnetizing current, and calculations of no-load current. Calculations of losses and efficiency. Computer-aided design of induction motor, generalized flow chart for design of an induction motor.

Text Books

1. M. G. Say–Theory and Performance and Design of A.C. Machines,3rd Edition, ELBS London.
2. A.K. Sawhney–A Course in Electrical Machine Design, Dhanpat Rai and Sons, New Delhi
3. K. G. Upadhyay- Design of Electrical Machines, New Age Publication
4. R. K. Agarwal–Principles of Electrical Machine Design, S. K. Katariya and Sons.

Reference Books

1. Vishnu Murti, "Computer Aided Design for Electrical Machines", B. S. Publications.AShanmuga
2. Sundaram, G. Gangadharan, R. Palani,-Electrical Machine Design Data Book,3rd Edition, 3rd Reprint 1988- Wiley Eastern Ltd.,- New Delhi.
3. Bharat Heavy Electricals Limited, Transformers - TMH.
4. M.V. Deshpande, "Electrical Machine Design" Third Edition, 2009, PHI Learning Pvt Ltd.

NPTEL/MOOC Course:

2. NPTEL/MOOC Course on Three-phase Transformer Design/Three-phase Induction Motor Design.

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	Assignment 1 (Based on Units I and II) (Deadline: before In-sem)	5
2	Assignment 2 (Based on Units III and IV) (Deadline: before End-sem)	5
3.	LMS Test (Best 5 out of a Minimum of 10)	5
4.	Class Test (Before Endsem on Units III, IV, V)	5

T.Y. B.Tech. Pattern:2023 Semester: VI (Electrical Engineering) 2306313: Computer-Aided Machine Design Lab		
Teaching Scheme:	**Credit Scheme: 1**	**Examination Scheme:**
Practical: 2 Hrs./Week	**PR: 1**	**Oral: 25 Marks** **TW: 25 Marks**

Prerequisite Courses: Transformer and Induction machines, Synchronous and Special Purpose machines

Course Objectives: The objectives of the course are to
1) Develop analytical/logical skills to design Electrical Machines.
2) Enable students to analyze the performance of three-phase transformers and three-phase induction motors for various design constraints.

Course Outcomes: On completion of the course, students will be able to –

	Course Outcomes	Bloom's Level
CO1	Explain the heating and loss-dissipation modes of electrical machines	2-Understand
CO2	Describe the procedure of design of three-phase transformers and three-phase induction motors	2-Understand
CO3	Design the three-phase transformers and three-phase induction motors for the given data in a group or individually	3-Apply
CO4	Analyze the three-phase transformers and three-phase induction motors to evaluate the performance in a group or individually	4-Analyze, 5-Evaluate

List of Laboratory Experiments
All the sheets on the design of electrical machines given are compulsory.

Sr. No.	Laboratory Experiments	COs Mapped
1	Study the construction and assembly of a three-phase transformer and prepare a design report. (Sheet in CAD)	CO1, CO2, CO3, CO4
2	Design and draw a layout of a single-layer three-phase winding. (Sheet in CAD)	CO2, CO3
3	Design and draw a layout of a double-layer three-phase winding. (Sheet in CAD)	CO2, CO3
4	Design and draw a layout of three-phase mush winding. (Sheet in CAD)	CO2, CO3
5	Draw the assembly of a three-phase induction motor. (Sheet in CAD)	CO1, CO2, CO3, CO4
6	**Industrial Visit:** Industrial visit to a transformer and Induction motor manufacturing / repairing unit.	CO1, CO2, CO3, CO4

Guidelines for Laboratory Conduction

1. All the sheets are to be prepared using CAD software.
2. NPTEL/MOOC/Training course on three-phase Transformer Design/three-phase Induction Motor Design is compulsory.

Guidelines for Student's Lab Journal

The student's Lab Journal should contain:

- Five sheets plotted using CAD software
- Sheet reports on the design of three three-phase transformers.
- Sheet reports on the design of three-phase induction motor stator windings.
- **Industrial Visit Report:** Industrial visit to a transformer OR Induction motor manufacturing / repairing unit.

Guidelines for Termwork Assessment
Each experiment from the lab journal is assessed for thirty marks based on three rubrics. Rubric R-1 for timely completion, R-2 for understanding and R-3 for presentation/journal writing, where each rubric carries ten marks.

T.Y.B.Tech.
Pattern:2023 Semester: VI (Electrical Engineering)
2306312: Electrical Installation, Maintenance and Testing

Teaching Scheme:	Credit Scheme:	Examination Scheme:
Theory:3 Hrs./Week	**TH: 3**	**Continuous Comprehensive Evaluation: 20Marks** **InSem Exam: 20Marks** **EndSem Exam: 60Marks**

Prerequisite Courses: Fundamentals of Electrical Engineering, Transformers and Induction Machines, Synchronous and Special Purpose Machines, Measurements and Instrumentations

Course Objectives: The objectives of the course are to
1. Introduce electrical safety procedures and protocols
2. Provide exposure to various Earthing systems.
3. Demonstrate the importance and necessity of the maintenance of the electrical equipment.
4. Enable students to classify different types of distribution supply systems and determine the economics of the distribution system.
5. Empower students to carry out estimation and costing of internal wiring for residential and commercial installations.

Course Outcomes: On completion of the course, students will be able to–

	Course Outcomes	Bloom's Level
CO1	Define electrical safety protocols, statutory regulations, types of fire extinguishers, and essential components of earthing systems.	1 – Remember
CO2	Explain the principles of system and equipment earthing, maintenance strategies, and condition monitoring techniques used in electrical systems.	2 – Understand
CO3	Apply standard testing procedures to assess insulation resistance, earth resistance, and performance of transformers, cables, and electrical installations.	3 – Apply
CO4	Analyze and estimate voltage drops in distribution systems, determine optimal conductor size using Kelvin's Law, and evaluate material requirements for installations.	4 – Analyze

COURSE CONTENTS

Unit I	Electrical Safety	8hrs	CO1,CO2

Contents of the first aid box, treatment for cuts, burns and electrical shock. Procedures for first aid (e.g. removing a casualty from contact with a live wire and administering artificial respiration). Various statutory regulations (Electricity supply regulations, factory acts and Indian electricity rules of Central Electricity Authority (CEA), Classification of hazardous area. (Introduction to OSHA)
Safety regulations & measures, Indian Electricity Supply Act 1948-1956, Factory Act 1948, Fire extinguishers – types &their operations, fixed installation & portable devices.

Unit II	Earthing	8hrs	CO1,CO2

Necessity of earthing, system earthing: advantage of neutral earthing of generator in power

station, equipment earthing: objective, types of earth electrodes, earthing in extra high voltage & underground cable, earthing resistance – factors affecting, determination of maximum permissible resistance of earthing system, measurement of earth resistance: voltmeter-ammeter method, earth tester method, ohm meter method & earth loop tester method, comparison between equipment earthing & system grounding, earthing procedure – building installation, domestic appliances, industrial premises, earthing of substation, generating station & overhead lines. Tolerable step and touch voltages, Steps involved in the design of the substation Earthing grid as per IEEE standard 80-2013.			
Unit III	**Maintenance, Condition Monitoring and Testing**	**10hrs**	**CO2,CO3**
Maintenance: Importance and necessity of maintenance, different maintenance strategies like breakdown maintenance, planned/preventive maintenance and condition-based maintenance. Planned and preventive maintenance of transformer, Induction motor and Alternators. Polarization index, dielectric absorption ratio. **Condition Monitoring:** Thermography. Dissolved gas analysis, Induction motor fault diagnostic methods – Vibration Signature Analysis, Motor Current Signature Analysis. **Testing:** Understanding CAT Ratings & Using CAT-rated Instrument, Electrical Installation Testing Procedures- Insulation resistance test. Portable Appliance Tester and Earth resistance test. Testing of Power cables – Causes of cable failure, fault location methods and Remedial actions. Testing of the Transformer - Type tests and Routine tests.			
Unit IV	**Economics of Distribution Systems:**	**9hrs**	**CO4**
Classification of supply systems (State Only) (i) DC, 2-wire system, (ii) Single phase two wire ac system, (iii) Three phase three wire ac supply system, iv) Three phase four wire ac supply system. Comparison between overhead and underground systems (For above mentioned systems) based on volume requirement for the conductor. AC Distribution System: Types of primary and secondary distribution systems, calculation of voltage drops in AC distributors (Uniform and Non-Uniform Loading) (Numerical). Economics of power transmission: Economic choice of conductor (Kelvin's law) (Derivation and Numerical). Distribution Feeders: Design considerations of distribution feeders; radial and ring types of primary feeders' voltage levels, energy losses in feeders.			
Unit V	**Installation and estimation of the distribution system**	**10hrs**	**CO3,CO4**
Electrical installations, domestic, industrial, Wiring System, Internal distribution of Electrical Energy. Methods of wiring, systems of wiring, wire and cable, conductor materials used in cables, insulating materials mechanical protection. Types of cables used in internal wiring, multi-stranded cables, voltage grounding of cables, and general specifications of cables. **Accessories:** Main switch and distribution boards, conduits, conduit accessories and fittings, lighting accessories and fittings, fuses, important definitions, determination of size of fuse–wire, fuse units. Earthing conductor, earthing, IS specifications regarding earthing of electrical installations, points to be earthed. Determination of the size of the earth wire and earth plate for domestic and industrial installations. Material required for GI pipe earthing.			

Text Books

1. B. R. Gupta- Power System Analysis and Design, 3rd edition, Wheeler's Publication.
2. S. Rao, Testing Commissioning Operation and Maintenance of Electrical Equipment, Khanna Publishers.
3. S. L. Uppal - Electrical Power - Khanna Publishers, Delhi.
4. Handbook of condition monitoring by B. K. N. Rao, Elsevier Advanced Tech., Oxford

(UK).
5. S. K. Shastri – Preventive Maintenance of Electrical Apparatus – Katson Publication House.
6. B. V. S. Rao – Operation and Maintenance of Electrical Equipment – Asia Publication.
7. Handbook on Electrical Safety

Reference Books

1. P.S. Pabla –Electric Power Distribution, 5th edition, Tata McGraw Hill.
2. S. L. Uppal, Electrical Wiring and Costing Estimation, Khanna Publishers, New Delhi.
3. Surjit Singh, Electrical wiring, Estimation and Costing, Dhanpat Rai and Company, New Delhi.
4. Raina K.B. and Bhattacharya S.K., Electrical Design, Estimating and Costing, Tata McGraw Hill, New Delhi
5. B.D. Arora-Electrical Wiring, Estimation and Costing, - New Heights, New Delhi.
6. M.V. Deshpande, Elements of Power Station design and practice, Wheelers Publication.
7. S. Sivanagaraju and S. Satyanarayana, Electric Power Transmission and Distribution, Pearson Publication.
8. Power Equipment Maintenance and Testing (Power Engineering Book 32) by Paul Gill

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr. No.	**Sr. No.**	**Marks Allotted**
1	Assignment 1 (Based on Units I and II) (Deadline: before Insem)	5
2	Assignment 2 (Based on Units III and IV) (Deadline: before Endsem)	5
3	LMS (Best 5 sessions out of a Minimum of 10 sessions)	5
4	Class Test (Before Endsem on Units III, IV, V)	5

K.K.Wagh Institute of Engineering Education and Research, Nashik
(Autonomous from Academic Year 2022-23)

T.Y. B.Tech.
Pattern 2023 Semester: VI (Electrical Engineering)
2306314A: PLC and SCADA Automation

Teaching Scheme:	Credit Scheme:	Examination Scheme:
Theory:3 Hrs./Week	TH: 3	Continuous Comprehensive Evaluation: 20Marks InSem Exam: 20Marks EndSem Exam: 60Marks

Prerequisite Courses: Analog and Digital Circuits, Control System Engineering

Course Objectives: The objectives of the course are to

1. Introduce hardware, architecture and software for PLC and SCADA.
2. Enable students to program PLC and SCADA systems for selected industrial processes.
3. Provide exposure to the DCS architecture used in industrial automation.
4. Explore various industrial data communication protocols.

Course Outcomes: On completion of the course, students will be able to–

	Course Outcomes	Bloom's Level
CO1	Identify and recall the fundamental components and architecture of PLCs, SCADA systems, HMIs, and DCS in industrial automation.	1 – Remember
CO2	Explain the principles of PLC ladder-logic programming and SCADA communication protocols; describe HMI interfaces and DCS functionalities.	2 – Understand
CO3	Apply PLC programming to implement control sequences, configure HMI screens, and utilize SCADA protocols for data acquisition and monitoring.	3 – Apply
CO4	Apply PID control and motor-drive concepts using PLCs to achieve desired control actions in closed-loop systems.	3 – Apply
CO5	Analyze PLC–SCADA–DCS integrated systems to identify control issues, troubleshoot faults, and communicate solutions effectively.	4 – Analyze

COURSE CONTENTS

Unit I	Programmable Logic Controller (PLC)	10 hrs	CO1, CO2

Role of automation in Industries, Overview of **Industry 4.0 and Smart Manufacturing,** benefits of automation, Necessity of PLC, Definition, Historical background, Parts of a PLC, Block diagram of PLC, Principles of operation, PLC size & application, PLC hardware components, selection criterion, advantages and disadvantages, specifications, Electromagnetic control relays, Contactors, Manually & Mechanically operated switches, Sensors, Output control devices, Seal-in circuits, Electrical interlocking circuits, Safety PLCs and **fail-safe concepts**, Converting relay schematics into PLC ladder programs, Ladder Logic Program from a narrative description.

Unit II	PLC Programming	10 hrs	CO2, CO3, CO5

Introduction, IEC 61131-3 Standard, Types of PLC languages, Ladder diagram format, Ladder relay instructions, Ladder relay programming, Timers and counters, Program/Flow control instructions, Math instructions, Data manipulation, Data transfer instructions & special function instructions, PLC Installation Practices, Editing, and Troubleshooting: PLC enclosures, Electrical noise, Leaky inputs and outputs, Grounding, Voltage variations & surges, Program editing and commissioning, Preventive maintenance, Troubleshooting.

Unit III	Advanced Functions and Applications of PLC	09 hrs	CO2, CO3, CO4, CO5
PID Tuning methods, PID Module, **Real-time process control using PID in actual applications** (e.g., flow, pressure, temperature), AC Motor starters, Overload protection, VFD, DC Motor Controllers. Interfacing PLC to Motor Drives, Need and Advantages of using HMI, PLC-HMI interface, Developing ladder logic for Sequencing of motors, Car parking, Tank level control, Temperature control, Elevator, Bottle filling plant, Traffic light controller			
Unit IV	**SCADA System**	**09 hrs**	**CO1, CO2, CO3**
Introduction, definitions and history of Supervisory Control and Data Acquisition, typical SCADA system Architecture, important definitions HMI, MTU, RTU, communication means, Desirable Properties of SCADA system, advantages, disadvantages and applications of SCADA, Introduction to **popular SCADA platforms**: WinCC, Wonderware, Ignition; SCADA Protocols: Open systems interconnection (OSI) Model, TCP/IP protocol, Modbus model, Device Net, Control Net, Ether Net/IP, Process Field bus (Profibus).			
Unit V	**Distributed Control Systems (DCS)**	**07 hrs**	**CO1, CO2, CO5**
Introduction, History of DCS, DCS concept, Communication in DCS, Modes of DCS, DCS hardware & software, DCS structure, Architectural feature of DCS, DCS design considerations, Manual and redundant backup designs, Advantages & disadvantages. Integration of PLC, SCADA, with DCS and IIoT platforms			

Text Books

4. Frank Petruzzula, “Programmable Logic Controllers”, McGraw Hill, New York, 5th Edition, 2016
5. John W. Webb, Ronald A. Reis, “Programmable Logic Controllers: Principles and Applications”, PHI publication
6. Stuart A. Boyer, “SCADA: Supervisory Control and Data Acquisition”, Fourth Edition, ISA-The Instrumentation, Systems, and Automation Society, 2010
7. Curtis D. Johnson, “Process Control Instrumentation Technology”, Pearson New International, 8th Edition, 2013
8. Lukcas M. P, “Distributed Control Systems”, Van Nostrand Reinhold Co., New York, 1986

Reference Books

4. Gary Dunning, “Introduction to Programmable Logic Controllers”, Thomson Delmar Cengage Learning, 3rd Edition, 2005
5. J. R. Hackworth and F. D. Hackworth, “Programmable Logic Controllers: Principles and Applications”, Pearson publication
6. William Bolton, “Programmable Logic Controllers”, Elsevier Newnes, 6th Edition, 2015
7. John W. Webb and Ronald A. Reis, “Programmable Logic Controllers: Principles and Applications”, 5th Edition, Prentice Hall Inc., New Jersey, 2003
8. L. A. Bryan and E. A. Bryan, “Programmable Controller: Theory and Implementation”, 2nd Edition, Industrial Text Co., 1997
9. Ronald L. Krutz, “Securing SCADA Systems”, Wiley, 1st Edition, 2005
10. D. Popovic and V. P. Bhatkar, “Distributed Computer Control for Industrial Automation”, Marcel Dekker, Inc., New York, 1990

NPTEL Course:

3. https://nptel.ac.in/courses/108105062 [Industrial Automation and Control, IIT Kharagpur, Prof. S. Mukhopadhyay, Prof. S. Sen]

4. https://nptel.ac.in/courses/108105063 [Introduction to Industrial Automation and Control, IIT Kharagpur, Prof. S. Mukhopadhyay, Prof. S. Sen]
5. https://nptel.ac.in/courses/108105088 [Industrial Automation and Control, IIT Kharagpur, Prof. Alokkanti Deb]
6. https://nptel.ac.in/courses/108106022 [Energy Management Systems and SCADA, IIT Madras, Dr. K. Shanti Swarup]
7. https://nptel.ac.in/courses/106105195 [Introduction to Industry 4.0 and Industrial Internet of Things, IIT Kharagpur, Prof. Sudip Misra]
8. http://www.nitttrc.edu.in/nptel/courses/video/105105201/lec56.pdf
9. https://realpars.com/what-is-industrial-automation/
10. https://ial-coep.vlabs.ac.in/List%20of%20experiments.html
11. https://plc-coep.vlabs.ac.in/List%20of%20experiments.html
12. https://sa-nitk.vlabs.ac.in/List%20of%20experiments.html

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	Assignment 1 (Based on Units I and II) (Deadline: before Insem)	5
2	Assignment 2 (Based on Units III and IV) (Deadline: before Endsem)	5
3.	LMS Tests (Best 5 sessions out of a Minimum of 10 sessions)	5
4.	Class Test (Before End Sem on Units III, IV, V) OR Teacher-Defined Evaluation Tool	5

T.Y. B.Tech.
Pattern:2023 Semester: VI (Electrical Engineering)
2306314B: Application of Power Electronics in Power Systems

Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Theory:3 Hrs./Week	**TH-3**	**Continuous Comprehensive Evaluation:20Marks** **InSem Exam: 20Marks** **EndSem Exam: 60Marks**

Prerequisite Courses: Power Electronics, Power System Engineering, Power System Analysis

Course Objectives: The objectives of the course are to

1. Introduce the operation and control of the SVC and TCSC
2. Introduce concepts of IGBT-based FACTS controllers
3. Explain the operation Line Commutated Converter (LCC) based HVDC links
4. Introduce features of the voltage source converter-based HVDC link.

Course Outcomes: On completion of the course, students will be able to–

	Course Outcomes	**Bloom's Level**
CO1	Explain the challenges in AC transmission systems and justify the need for Flexible AC Transmission Systems (FACTS) and High Voltage Direct Current (HVDC) transmission technologies.	2-Understand
CO2	Describe the application of power electronic converters in FACTS and HVDC systems to improve power system stability and damping.	3-Apply
CO3	Analyze the operation and control strategies of voltage source converter (VSC)-based FACTS and HVDC systems.	4-Analyze
CO4	Assess the performance and effectiveness of various FACTS devices and HVDC transmission lines in real-world scenarios.	5-Evaluate

COURSECONTENTS

Unit I	**Introduction**	**9 hrs**	**CO2**

Reactive power control in electrical power transmission lines – load & system compensation, Uncompensated transmission line – shunt and series compensation. Need for HVDC Transmission, Comparison between AC & DC Transmission, Types of HVDC Transmission Systems.

Unit II	**Static Var Compensator (SVC) and Thyristor Controlled Series Compensator (TCSC)**	**9 hrs**	**CO1, CO3**

VI characteristics of FC + TCR, TSC + TCR, Voltage control by SVC – Advantages of slope in dynamic characteristics – Influence of SVC on system voltage – Design of SVC voltage regulator, Thyristor Controlled Series Compensator (TCSC), Concept of TCSC, Operation of the TCSC – Different modes of operation and applications.

Unit III	**Voltage Source Converter-Based FACTS Controllers**	**9 hrs**	**CO1, CO3**

Static Synchronous Compensator (STATCOM) – Principle of operation – V-I Characteristics. Applications: Steady-state power transfer – enhancement of transient stability – prevention of voltage instability. SSSC – operation of SSSC, V-I characteristics, Enhancement in Power transfer capability – UPSC – Operation Principle, Applications.

Unit IV	**Line Commutated HVDC Transmission**	**9 hrs**	**CO1, CO4**

Operation of Gratz bridge – Effect of delay in Firing Angle – Effect of commutation overlap – Equivalent circuit, Basic concept of HVDC transmission. Model of operations and control of power flow: CC and CIA mode of operation.

Unit V	VSC-Based HVDC Transmission	8 hrs	CO1, CO4

Basic 2-level IGBT inverter operation – 4 Quadrant operation – phase angle control – dq control – Control of power flow in VSC-based HVDC Transmission, Topologies of MTDC system.

Text Books

1. R.D. Begamudre, "Extra High Voltage AC Transmission Engineering", New Age Publishers, 2009
2. K.R. Padiyar, "HVDC Power Transmission Systems: Technology and System Reactions", New Age International, 3rd edition, 2017

Reference Books

1. Understanding of FACTS, Hingorani, N.G.; IEEE Press1996.
2. Heydt, G.T. Power Quality; Starsina Circle Publications, Indiana,1991.
3. Miller T. J. E. Static Reactive Power Compensation, John Wiley & Sons, New York, 1982
4. Flexible AC Transmission System.(FACTs).; YongHuaSong.;IEE1999.

NPTEL Course:

3. "High Voltage DC Transmission" https://nptel.ac.in/courses/108104013
4. "FactsDevices"https://onlinecourses.nptel.ac.in/noc23_ee58/preview

Guidelines for Continuous Comprehensive Evaluation of Theory Course

Sr. No.	Components for Continuous Comprehensive Evaluation	Marks Allotted
1	Assignment 1 (Based on Units I and II) (Deadline: before Insem)	5
2	Assignment 2 (Based on Units III and IV)(Deadline: before Endsem)	5
3.	LMS Tests (Best 5 out of a Minimum of 10)	5
4.	Simulation of IEEE paper to demonstrate FACTS or HVDC Technologies. OR Class Test (Before End Sem on Units III, IV, V)	5

K.K.Wagh Institute of Engineering Education and Research, Nashik
(Autonomous from Academic Year 2022-23)

T. Y. B. Tech. Pattern: 2023Semester: VI (Electrical Engineering) 2306315A: Renewable Energy Systems		
Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Theory: 3Hrs./Week	**Th - 3**	**Continuous Comprehensive Evaluation: 20Marks** **InSem Exam: 20Marks** **EndSem Exam: 60Marks**

Prerequisite Courses: Fundamentals of Electrical Engineering, Applied Physics and Applied Chemistry

Course Objectives: The objectives of the course are to

1. I**ntroduce** students to the classification and principles of various renewable energy sources, such as solar, wind, biomass, geothermal, ocean energy, and hydrogen.
2. **Explain** the working, design considerations, and applications of solar photovoltaic (PV) systems and bioenergy systems.
3. F**amiliarize** students with the technical and economic aspects of fuel cells and hydrogen energy systems, including storage and transportation.
4. E**ncourage** analysis of energy consumption patterns, integration of renewable energy with the grid, and comparison with conventional sources.

Course Outcomes: On completion of the course, students will be able to–

Course Outcomes		Bloom's Level
CO1	**Identify and describe** various renewable energy sources and their working principles.	1-Remember
CO2	**Illustrate** the design, working, and performance characteristics of different types of solar cells and photovoltaic modules.	2-**Understand**
CO3	**Analyze** the operation and efficiency of bioenergy systems, biogas plants, and their practical implementation	**4-Analyze**
CO4	**Evaluate** the suitability and performance of hydrogen and fuel cell technologies in various sectors and energy systems	**5- Evaluate**

COURSE CONTENTS			**COs mapped**
Unit I	**Fundamentals of Renewable Energy Technology**	**9 hrs.**	**CO1**

Concept of Renewable Energy Sources (RES), Review of renewable energy sector MNRE (Ministry of Power and MNRE website), Classification of RES, Solar, Wind, Geothermal, Biomass, Ocean energy sources, Hydrogen, Fuel cells, Comparison of renewable energy sources with non-renewable sources. Status of energy utilization. Energy consumption pattern & energy resources in India, Latest Renewable Energy Targets of India (2025/2030),

Unit II	**Photovoltaic Technology and Systems**	**9 hrs.**	**CO2**

Solar Photovoltaic: Introduction, p-n junctions. Types of Solar Cell, Wafer-based Silicon Cell, Thin film amorphous silicon cell, Thin Cadmium Telluride (CdTe) Cell, Copper Indium Gallium Selenide (CiGS) Cell, Thin film crystalline silicon solar cell, Solar Shingles.
Solar Photo Voltaic Module: Solar cell, solar module, solar array, series & parallel connections of cell, mismatch in cell, fill factor, effect of solar radiation and temperature on power output of module, I-V and power curve of module. Application of Solar PV system, Stand-alone, Grid connected, Hybrid System, solar lantern, solar street light, solar water pumping system, Roof top solar photovoltaic power

plant.Perovskite Solar Cells, Floating Solar Power Plants, Agrisolar

Unit III	**Biogas Technology**	**9 hrs.**	**CO3**

Bio-energy: Introduction, Pyrolysis of Biomass to produce solid, liquid and gaseous fuels. Biomass gasification, Types of gasifier.
Biogas: Biogas technology and the generation of power from biogas. Mechanisms, Conditions for optimum production. Raw material for biogas: Mechanical conversion of biogas. Design & use of a different commercial-sized Biogas Plant. Types of biogas plants, biogas generation, factors affecting biogas generation and usage, design considerations, advantages and disadvantages of biogas.

Unit IV	**Hydrogen Technology**	**9 hrs.**	**CO4**

Introduction to Hydrogen technology, Significance of H2 in different sectors, Hydrogen production processes, Different Types of Electrolizer: Acidic, Alkaline and Solid Oxide, Chemical reactions, Storage of hydrogen in solid, liquid, and gaseous form. Hydrogen transportation methods, National Hydrogen Mission

Unit V	**Fuel Cell**	**9 hrs.**	**CO5**

Definition of fuel cell, Introduction to Fuel cell technology, types of fuel cells, Working of PEM FC, V-I characteristics of fuel cell, Comparison of fuel cells, Advantages and disadvantages of fuel cells, Application of FC.

TextBooks

1. Renewable Energy, theory and practice, N. S. Rathore, N.C. Panwar, A. K. Kurchania, 2008
2. Garg, H.P. and J. Prakash 2000. Solar Energy Fundamentals and Applications. 1St Revised Edition. Tata McGraw-Hill, New Delhi
3. Khandelwal, K.C. & S.S. Mandi. 1990. Biogas Technology.
4. Fuel cells: principles and applications. B Viswanathan, M AulicScibioh, Universities Press, First Edition (1 January 2006)

Reference Books

1. Bansal N.K., Kleemann M. &Meliss Michael. 1990. Renewable Energy Sources & Conversion Technology; Tata McGraw-Hill Publishing Company, New Delhi.
2. Alan L: Farredbruch& R.H. Buse. 1983. Fundamentals of Solar. Academic Press, London.
3. S.Rao and B.B.Parulekar.Energy Technology, Third Revised Edition.Khanna Publication, New Delhi

Guidelines for Continuous Comprehensive Evaluation of Theory Course

Sr. No.	Components for Continuous Comprehensive Evaluation	Marks Allotted
1	Assignment 1 (Based on Units I and II) (Deadline: before Insem)	5
2	Assignment 2 (Based on Units III and IV) (Deadline: before Endsem)	5
3.	LMS (Best 5 sessions out of a Minimum of 10 sessions)	5
4.	Class Test (Before End Sem on Units III, IV, V)	5

T. Y. B. Tech.
Pattern: 2023Semester: VI (Electrical Engineering)
2306315B: Energy Audit and Management

Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Theory:3 Hrs./Week	**TH-3**	**Continuous Comprehensive Evaluation: 20Marks** **InSem Exam: 20Marks** **EndSem Exam: 60Marks**

Prerequisite Courses: Fundamentals of Electrical Engineering, Power Systems

Course Objectives: The objectives of the course are to
1. Explain the importance of energy and energy security.
2. Enable students to use the format of energy management and energy policy.
3. Demonstrate various tools of Demand Control and calculate the economic possibility of the energy-saving option.

Course Outcomes: On completion of the course, students will be able to–

	Course Outcomes	**Bloom's Level**
CO1	Describe BEE Energy Policies and the Energy ACT.	2- Understand
CO2	Explore and use simple data analytics tools for demand-side management Measures for managing utility systems.	3- Apply
CO3	Identify appropriate energy conservation methods for electric and thermal utilities.	4- Analyze
CO4	Evaluate the economic feasibility of energy conservation projects.	5- Evaluate

COURSE CONTENTS

Unit I	**Energy Scenario and Management**	**10hrs**	**CO1**

Classification of Energy resources, commercial energy production, and final energy consumption. Energy needs of a growing economy, short and long-term policies, energy sector reforms, energy security, importance of energy conservation, energy and environmental impacts, introduction to CDM, UNFCCC, Paris treaty, emission check standard, salient features of Energy Conservation Act 2001 and Electricity Act 2003. Latest amendments in the Energy Conservation and Electricity Act. Indian and Global Energy Scenario. Introduction to IE Rules. Study of Energy Conservation Building Code (ECBC).

Definition, Objective and Principles of Energy Management, Energy Management Strategy and skills, key elements in energy management, force field analysis, energy policy, format and statement of energy policy, Organization setup and energy management. Responsibilities and duties of an energy manager under the latest Act. Energy Efficiency Programs. Energy monitoring systems.

Unit II	**Demand Side Management**	**09hrs**	**CO1, CO2**

Supply-side management (SSM), Generation system up-gradation, constraints on SSM. Demand side management (DSM), advantages and barriers, and implementation of DSM. Use of the demand-side management in agricultural, domestic and commercial consumers. Demand management through tariffs (TOD). Impact of Power factor on tariff. Apparent energy tariffs. Role of renewable energy sources in energy management, direct use (solar thermal, solar air conditioning, biomass) and indirect use (solar, wind, etc.) Introduction to ISO 50001- Energy Management.

Unit III	**Energy Audit**	**08 hrs**	**CO1, CO3**

Definition, need of energy audits, types of audits, procedures to follow, data and information analysis, Introduction to Data Analytics, data quality processing, clustering techniques, pattern mining, regression and classification. Relevance of Data Analytics in Audit, energy audit instrumentation, energy consumption–production relationship, pie charts. Sankey diagram, Cusum technique, least

squares method and numerical based on it. Outcome of energy audit and energy saving potential, action plans for implementation of energy conservation options. Benchmarking the energy performance of an industry. Energy Audit reporting format – Executive Summary, Detailing of report.			
Unit IV	**Financial Analysis**	**08 hrs**	**CO2, CO3**
Financial appraisals; criteria, simple payback period, return on investment, net present value method, time value of money, break-even analysis, sensitivity analysis and numerical based on it, cost of Energy, cost of generation, Energy Audits case studies – Sugar Industry, Steel Industry, Paper and Pulp industry.			
Unit V	**Energy Conservation**	**10hrs**	**CO2, CO3, CO4**
Energy Conservation of a) Motive power (motor and drive system). b) Illumination, c) Heating systems (boiler and steam systems), d) Ventilation(Fan, Blower and Compressors) and Air Conditioning systems, e) Pumping System, f) Cogeneration and waste heat recovery systems, g) Utility industries (T and D Sector)and Performance Assessments.			

Text Books

9. Guidebooks for National Certification Examination for Energy Managers/Energy Auditors Book 1, General Aspects (available online)
10. Guidebooks for National Certification Examination for Energy Managers/Energy Auditors Book 2 – Thermal Utilities (available online)
11. Guidebooks for National Certification Examination for Energy Managers/Energy Auditors Book 3- Electrical Utilities (available online)
12. Guidebooks for National Certification Examination for Energy Managers/Energy Auditors Book 4 (available online)

Reference Books

1. Guidebooks for National Certification Examination for Energy Managers/Energy Auditors Book 4 (available online)
2. Utilization of electrical energy by S.C. Tripathi, Tata McGraw-Hill.
3. Energy Management by W.R. Murphy and Mackay, B.S. Publication.
4. Generation and Utilization of Electrical Energy by B.R. Gupta, S. Chand Publication
5. Energy Auditing Made Simple by Balasubramanian, Bala Consultancy Services.
6. A General Introduction to Data Analytics by Andre Carvalho and TomášHorváth, Wiley Inc. First Edition 2019.

Guidelines for Continuous Comprehensive Evaluation of Theory Course

Sr. No.	Components for Continuous Comprehensive Evaluation	Marks Allotted
1	Assignment 1 (Based on Units I and II) (Deadline: before Insem)	5
2	Assignment 2 (Based on Units III and IV) (Deadline: before Endsem)	5
3.	LMS Tests (Best 5 out of a minimum of 10)	5
4.	Class test (Before Endsem) Based on Units III to V OR Energy Audit Case Studies	5

K.K.Wagh Institute of Engineering Education and Research, Nashik
(Autonomous from Academic Year 2022-23)

T. Y. B.Tech. Pattern 2023 Semester: VI(Electrical Engineering) 2306316A: PLC and SCADA Automation Lab		
Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Practical: 2 Hrs./week	**PR: 1**	**Term Work: 25 Marks Oral: 25 Marks**

Prerequisite Courses: Analog and Digital Circuits, Control System Engineering

Course Objectives: The objectives of the course are to

5. Develop a deeper understanding of concepts in industrial automation.
6. Connect theoretical PLC, SCADA, and DCS knowledge to physical applications
7. Provide exposure to experimental skills like the use of programming software, design of a ladder program, design of SCADA screens, hardware interfacing in a step-by-step manner, observation, and analysis

Course Outcomes: On completion of the course, students will be able to–

CO	Course Outcomes	Bloom's Level
CO1	Select appropriate components/equipment for industrial automation.	2-Understand
CO2	Interface the PLC with hardware devices to develop the ladder program for industrial applications in groups or individually	3-Apply
CO3	Design and interface the PLC, SCADA and DCS systems for industrial applications in groups or individually	6-Create

List of Laboratory Experiments

At least 8 experiments are to be performed out of the following list:
a) Experiments No. 1, 9, 10, 12 and 13 are compulsory.
b) Any 3experiments should be conducted from experiment numbers 2 to 8, 10, 14, and 15.

Sr. No.	Laboratory Experiments	COs Mapped
1	Understand the PLC and various components. Interfacing of discrete input and output devices with PLC for ON and OFF operation. Verify all logic gates.	CO1, CO2
2	Set/Reset (Latch/Unlatch) operation: many push buttons for ON (set/latch) and one push button for OFF (reset/unlatch) operation.	CO1, CO2
3	Application using a combination of a counter and a timer for lamp ON/OFF operation.	CO1, CO2
4	DOL starter and star delta starter operation by using a PLC.	CO1, CO2
5	PLC-based thermal (temperature) ON/OFF control using an analog input device.	CO1, CO2
6	Tank level control by using PLC.	CO1, CO2
7	PLC-based speed, position, flow, level, and pressure measurement system. (Any one or two applications)	CO1, CO2
8	To study the operation of single-acting cylinders, double-acting cylinders with 3-2 valve& 5-2 valve	CO1
9	PLC interfaced with SCADA and status read/command transfer operation.	CO1, CO2, CO3
10	Parameter reading of PLC in SCADA, for thermal (temperature) control	CO1, CO2, CO3

	performed in PLC.	
11	Reporting and trending in the SCADA system.	CO1, CO2, CO3
12	To interface VFD with PLC and monitoring and control by using SCADA.	CO1, CO2, CO3
13	To understand the hardware and software platforms for DCS	CO1, CO3
14	Study of Alarm Management System in DCS.	CO1, CO3
15	Tune the PID controller for the heat exchanger using DCS. (Virtual Lab).	CO1, CO3
16	Industrial Visit (Compulsory for all students).	CO1, CO2, CO3

The list of experiments given above is only suggestive. The Instructor may add new experiments as per the requirements of the course.

Guidelines for Laboratory Conduction

7. The teacher will brief the given experiment to students for its procedure, observations, calculations, and outcome.
8. The apparatus and equipment required for the allotted experiment will be provided by the lab technician.
9. Students will perform the allotted experiment in a group (3-4 students in each group) under the supervision of faculty and a lab technician.
10. After performing the experiment, students will check their readings and calculations from the teacher.
11. After checking, they have to write the conclusion on the final results.
12. A minimum of 4 sets of the experiment should be made ready for the conduction of the experiment in a batch for hardware experiments.

Guidelines for Student's Lab Journal

The write-up should include a title, aim and apparatus, circuit or block diagram, waveforms, brief theory, procedure, observations, graphs, calculations, conclusion, and answers to the questions, if any.

Guidelines for Term Work Assessment

Each experiment from the lab journal is assessed for thirty marks based on three rubrics. Rubric R-1 for timely completion, R-2 for understanding, and R-3 for presentation/journal writing, where each rubric carries ten marks.

K.K.Wagh Institute of Engineering Education and Research, Nashik
(Autonomous from Academic Year 2022-23)

T.Y. B.Tech. Pattern:2023Semester:VI(Electrical Engineering) 2306316B: Application of Power Electronics in Power System Lab		
Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Practical:2Hrs./Week	**PR:1**	**Term Work: 25 Marks Oral:25 Marks**

Prerequisite Courses: Power Electronics, Power System Engineering, Power System Analysis

Course Objectives: The objectives of the course are to
1. Provide knowledge about modern trends in Power Transmission Technology
2. Make students understand the applications of power electronics in the control of power transmission
3. Educate students on the use of software such as PSCAD and MATLAB for power transmission and control

Course Outcomes: On completion of the course, students will be able to–

	Course Outcomes	**Bloom'sLevel**
CO1	Conduct group experiments, document findings through detailed lab reports, and present results effectively, demonstrating clear communication skills.	3-Apply
CO2	Model and simulate FACTS controllers and HVDC transmission systems using various control strategies to understand their behavior and performance under different conditions.	4-Analyze
CO3	Interpret simulation results from FACTS and HVDC systems and critically evaluate the performance of these devices in terms of stability, efficiency, and control effectiveness.	5-Evaluate
CO4	Design and simulate various FACTS controllers and HVDC transmission lines using MATLAB or PSCAD, integrating suitable control mechanisms for optimization and stability.	6-Create

List of Laboratory Experiments

At least 6 experiments are to be performed from the following list:

Sr. No.	**Laboratory Experiments**	**Cos Mapped**
1	Simulation of abc-dq0 and dq0 transformation using power variance and invariance method.	CO1, CO2, CO3, CO4
2	Simulation and analysis of the performance of a 6-pulse converter.	CO1, CO2, CO3, CO4
3	Simulation and analysis of the performance of the FC-TCR scheme for the given power system.	CO1, CO2, CO3, CO4
4	Simulation and analysis of the performance of the STATCOM scheme for the given power system.	CO1, CO2, CO3, CO4
5	Simulation and analysis of the performance of the TCSC scheme for the given power system.	CO1, CO2, CO3, CO4
6	Simulation and analysis of the performance of the SSSC scheme for the given power system.	CO1, CO2, CO3, CO4

7	Simulation and analysis of the performance of an active power filter scheme for the given power system.	CO1, CO2, CO3, CO4
8	Simulation and analysis of the performance of the DVR scheme for the given power system.	CO1, CO2, CO3, CO4
9	Simulation and analysis of the performance of a 12-pulse converter.	CO1, CO2, CO3, CO4
10	Simulation and analysis of the performance of HVDC lines for the given power system.	CO1, CO2, CO3, CO4

Guidelines for Laboratory Conduction

1. The teacher will brief the given experiment to students for its procedure, observations, calculations, and outcome.
2. The apparatus and equipment required for the allotted experiment will be provided by the lab technician.
3. Students will perform the allotted experiment in a group (3-4 students in each group) under the supervision of faculty and a lab technician.
4. After performing the experiment, students will check their readings and calculations from the teacher.
5. After checking, they have to write the conclusion on the final results.
6. A minimum of 4 sets of the experiment should be made ready for the conduction of the experiment in a batch for hardware experiments.

Guidelines for Student's Lab Journal

The write-up should include a title, aim and apparatus, circuit or block diagram, waveforms, brief theory, procedure, observations, graphs, calculations, conclusion, and answers to the questions, if any.

Guidelines for Term Work Assessment

Each experiment from the lab journal is assessed for thirty marks based on three rubrics. Rubric R-1 for timely completion, R-2 for understanding, and R-3 for presentation/journal writing, where each rubric carries ten marks.

T.Y. B.Tech.
Pattern: 2023 Semester: VI (Electrical Engineering)
2306317: Communication Systems

Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Theory: 3hrs/week	**TH: 3**	**Continuous Comprehensive Evaluation: 20 Marks** **InSem Exam: 20 Marks** **EndSem Exam: 60 Marks**

Prerequisite Courses: Digital Signal Processing

Course Objectives: The objective of the course is to make the student aware of the importance of communication in the electrical sector and describe some common analog and digital modulation techniques.

Course Outcomes: On completion of the course, students will be able to–

	Course Outcomes	**Bloom's Level**
CO1	Describe the structure of analog and digital communication system	2-Understand
CO2	Demonstrate the effect of noise and distortion on communication	3- Apply
CO3	Explain the operation of analog and digital modulation techniques	2-Understand
CO4	Select the appropriate communication technique for data transfer	2-Understand

COURSE CONTENTS

Unit I	**Fundamentals of a communication system**	**8 hrs**	**CO1**

Importance of communication in electrical systems; Basic structure of any communication system; Overview of analog to digital and digital to analog conversion; Classification of signals; Fourier series; Fourier transform

Unit II	**Noise and distortion**	**10 hrs**	**CO2**

External and internal noise; Types; Noise due to multiple amplifiers in cascade and to the reactive circuit; Noise figure and noise temperature; Signal distortion over a communication channel; Types of distortion; Multipath effect; Fading channels; Signal energy and ESD; Essential bandwidth; Signal power and PSD

Unit III	**Amplitude and angle Modulation**	**12 hrs**	**CO1, CO3, CO4**

Introduction to amplitude modulation; Bandwidth and power of AM wave; AM modulators and demodulators – DSBSC, SSBSC, VSBSC; FDM and OFDM; FM and PM; Single tone FM and classification; WBFM and NBFM; Generation of WBFM- Direct and indirect method; FM demodulation –Frequency and phase discrimination method

Unit IV	**Basics of digital communication**	**10 hrs**	**CO1, CO3, CO4**

Sampling and A/D conversion; Aliasing effect and anti-aliasing filter; Time-division multiplexing (TDM); Synchronous and asynchronous TDM; Uniform and non-uniform quantization; A-law and μ-law; Pulse communication; Analog and digital pulse modulation; PAM; PTM; PCM; Delta and adaptive delta modulation

Unit V	**Digital data modulation**	**5 hrs**	**CO3, CO4**

ASK, OOK, FSK, PSK, QPSK, DPSK, QAM

Text Books
1. B. P. Lathi, Zhi Ding, "Modern Digital And Analog Communication Systems", Oxford University Press, 4th Edition, 2017. 2. S. S. Haykin, M. Moher, "Introduction to Analog and Digital Communications", Thomson learning, 2nd Edition, 2007. 3. J. G. Proakis, M. Salehi, "Fundamentals of Communication Systems", Pearson Education, 1st Edition, 2014.
Reference Books
1. S. Sharma, "Communication Systems (Analog And Digital)", S. K. Kataria& Sons, 1st Edition, 2013. 2. R. P. Singh, S. Sapre, "Communication Systems: Analog and Digital", McGraw Hill Education, 3rd Edition, 2017. 3. K. Sam Shanmugam, "Digital and Analog Communication Systems", Wiley India Pvt Ltd, 2006.

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	Assignment 1 (Based on Units I and II) (Deadline: before Insem)	5
2	Assignment 2 (Based on Units III and IV) (Deadline: before Endsem)	5
3.	LMS Tests (Best 5 sessions out of a Minimum of 10 sessions)	5
4.	Class test (Before Endsem) Based on Units III to V OR Course Teacher-Defined Evaluation Tool	5

K.K.Wagh Institute of Engineering Education and Research, Nashik
(Autonomous from Academic Year 2022-23)

T.Y. B.Tech. Pattern: 2023 Semester: VI (Electrical Engineering) 2306318: Massive Open Online Course (LHSM)		
Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Theory: 2 Hrs./week	**TH:2**	**Continuous Comprehensive Evaluation: 50 Marks**
Course Content		
Students have to select one of the following Online Courses available on the Swayam Platform and complete the course. Students have to submit the course completion certificate to the course teacher/coordinator.		
The List of Courses will be declared at the beginning of the semester.		

.

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	Grading of the online course will be taken as it is and will be rounded to 50 marks.	50

Note: CO-PO-PSO Mapping will be decided after selecting the course and will be included in the Course Handout. The list of available courses is as follows.

T.Y. B.Tech. Pattern: 2023 Semester: VI (Electrical Engineering) 2306319: Industry Connect Lab		
Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Tutorial: 1 Hr./Week **Practical: 2 Hrs./Week**	**TU: 1** **PR: 1**	**TU: 25 Marks** **Oral: 25 Marks**

Prerequisite Courses: All core courses and elective courses studied in the previous semester

Course Objectives: The objectives of the course are to

1. Provide exposure to industrial testing procedures and practices
2. Introduce the latest trends in the industry

Course Outcomes: On completion of the course, students will be able to –

	Course Outcomes	Bloom's Level
CO1	List out the various jobs and routine activities of the various sections of the industry	2-Understand
CO2	Understand the documentation needed from product design to marketing	2-Understand
CO3	Explain the product testing procedures with respect to standard practices	2-Understand

Course Content

TH	The theory classes of this course will be delivered by industry professionals from various industries, where they will explain the various works completed by the various sections, highlighting one particular section in a detailed manner. Sessions will also cover the latest advancements in the Technical field. Industries in all the sectors (core, IT, service, etc.) will be covered. A minimum of 12sessions will be covered.	**COs Mapped:** CO1, CO2, CO3
LAB	The lab sessions will cover the following components 1. Student Industrial visits to see testing procedures in industries. 2. Industrial long tours (2-3 days) 3. Mini project in industry by a group of students 4. Random industry visits by the students to understand the industry problems 5. Electrical engineering product exploration 6. Visiting the industrial exhibitions and expos by students 7. Industrial case studies	**COs Mapped:** CO1, CO2, CO3

Guidelines for Laboratory Conduction
All the guidelines will be decided separately for each lab activity as and when it is planned and will be mentioned in the course handout.
Guidelines for Students' Lab Journal
All the guidelines will be decided separately for each lab activity.
Guidelines for Term Work/Tutorial Assessment
Each experiment from the lab journal is assessed for thirty marks based on three rubrics. Rubric R-1 for timely completion, R-2 for understanding, and R-3 for presentation/journal writing, where each rubric carries ten marks.

Note: CO-PO-PSO Mapping will be done after the finalization of the course handout at the time of commencement of classes.

K.K.Wagh Institute of Engineering Education and Research, Nashik
(Autonomous from Academic Year 2022-23)

T.Y. B.Tech. **Pattern: 2023 Semester: VI (Electrical Engineering)** **2316320: Software for Research**		
Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Practical: 2 Hrs./Week	**PR: 1**	**Term Work: 50 Marks**

Prerequisite Courses: All core courses and elective courses studied in the previous semester

Course Objectives: The objectives of the course are to
1. Provide exposure to professional software
2. Enable students to use the software for simulation, design and result analysis.
3. Empower students to write research studies, understand and write research papers.

Course Outcomes: On completion of the course, students will be able to –

	Course Outcomes	**Bloom's Level**
CO1	Construct simple circuits and models using various simulation platforms	2-Understand
CO2	Solve the simulation circuit and model, and check the values	3-Apply
CO3	Integrate various subsystems to form the whole system	4-Analyze
CO4	Test the performance with respect to standard performance indices	5-Evaluate

Course Content

LAB	Using the following simulation platforms, experiments are to be completed 1. ETAP, 2. PSCAD, 3. Ansys, 4. MATLAB 5. LaTeX The experiments are conducted in such a way that the results are documented to write a research paper, or it can be a simulation of the published research paper (published in a peer-reviewed journal) The following experiments are to be conducted in a sequence 1. To explore recent trends in the field and identify suitable project areas 2. To conduct a structured literature survey and identify a base paper 3. To understand the Software environment and simulate basic systems 4. To replicate the base paper simulation model 5. To observe the effect of parameter changes in the base model 6. To write a short research paper based on simulation results 7. To present simulation results and receive feedback	**COs Mapped CO1, CO2, CO3, CO4**

Guidelines for Laboratory Conduction
1. The faculty has to confirm the research papers on various simulation platforms' application to electrical engineering problems and explain them to the students during the lab 2. Design the experiments in such a way that the final result of the three experiments is a simulation of a research paper 3. This is considered the course work for the project that will be carried out in the final year by a group of students. This lab is expected to have a systematic selection of the research paper relevant to the project work and simulation of the same using the professional software given above

Guidelines for Student's Lab Journal
1. Students have to form groups of 4 for this lab, which will work as a project team for the next year. 2. Students will mathematically solve the problem and will verify it using the simulation platform. 3. The write-up will have the solved solution and a printout of the simulation.
Guidelines for Term Work Assessment
1. Each experiment from the lab journal is assessed for thirty marks based on three rubrics. 2. Rubric R-1 for timely completion, R-2 for understanding, and R-3 for presentation/journal writing, where each rubric carries ten marks.

T. Y. B. Tech
Pattern: 2023 Semester: VI (Electrical Engineering) (EXIT Course)
2306321: Internship

Teaching Scheme:	Credit Scheme:	Examination Scheme:
Theory: NA	**2**	**Term work: 100 Marks**

Course Objectives: The objectives of the course are to
1. Encourage and provide opportunities for the students to acquire professional learning experiences.
2. Provide exposure to handling and using various tools, measuring instruments, meters, and technologies used in industries.
3. Enable students to develop professional and employability skills and expand their professional network.

Course Outcomes: On completion of the course, students will be able to–

	Course Outcomes	Bloom's Level
CO1	Operate various meters, measuring instruments, and tools used in industry efficiently and develop technical competence.	1-Remember 2-Understand
CO2	Understand the working culture and environment of the Industry and get familiar with various departments and practices in the industry.	4-Analyze 5-Evaluate
CO3	Apply internship learning in engineering project work, i.e. topic finalization, project planning, hardware development, result interpretations, report writing, etc.	3-Apply
CO4	Create a professional network and learn about ethical, safety measures, and legal practices.	1-Remember 2-Understand

Internship Guidelines for Students

A. Before Joining the Internship
1. Look for internships in the industries provided by the department.
2. The internship duration should be 4 weeks.
3. Ask for the internship request letter from the respective class coordinator. He will appoint a guide for you.
4. Mentoring of the internship activity will be done through your Guide. You are informed to report to your guide from time to time.

B. During Internship
1. Keep the internship record book with you.
2. Note down all the details date-wise in the internship record book. Take the signature of your industry mentor daily.
3. The internship record book will help you to write your final internship report. Simultaneously, you can start writing internship reports.
4. Maintain an institutional culture while working in the industry.

C. After Internship
1. Submit the Internship Record book and Internship report. Both are in hard copy.
2. Submit all your details within 15 days of completion of the Internship.
3. After the internship, the presentation schedule will be displayed.
4. The internship course will be assumed to be completed only after the final presentation. The date of presentation will be declared at least 10-15 days before the actual date.

Evaluation and Assessment of Internship			
Sr. No.	**Evaluation Parameter**	**Marks**	**Remarks**
1	Internship Record Book	25	Maintain all the records. This should be handwritten and submitted in hard copy. It will be evaluated based on 1. Proper and timely documented entries 2. Adequacy and quality of information 3. Data, observations, and discussions recorded 4. Thought process and recording techniques used 5. Organization of the information
2	Internship Report	25	Submit your report as per the guidelines. It should have **1. Starting pages:** Certificates, declaration, abstract, table of contents, figures, tables, etc. **2. Chapter 1:** Introduction: A Brief about the company, industry or organization, objectives, motivation, and organization of the report **3. Chapter 2:** Problem Identification/Problem statement/objectives and scope/expected outcomes **4. Chapter 3:** Methodological details **5. Chapter 4:** Results / Analysis /inferences and conclusion **6. Chapter 5:** Suggestions/Recommendations for improvement to the industry, if any **7. End Pages:** Acknowledgement and references
3	Post-Internship Evaluation	50	Evaluation will be done by both industry and department mentors, based on the presentation criteria given below 1. Internship Identification and Selection 2. The Problem Studied with objectives and expected outcomes 3. Consideration of environmental/ Social /Ethical/ Safety measures/Legal aspects. 4. Methodology/System/Procedure Q&A 5. Block diagram, flow-chart, algorithm, system description Q&A 6. Final results, discussions, suggestions, comments, etc. Q&A 7. Presentation and Communication
Total Marks		**100**	**Timely completion of activities is essential for all the above**

T. Y. B. Tech.
Pattern: 2023Semester: VI (Electrical Engineering) (EXIT Course)
2306322: Electrical Control Panel Design

Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Theory: 2 hrs./week **Practical: 2 hrs./week**	**TH: 2** **PR: 2**	**Term Work: 50 Marks** **InSem Exam: 20 Marks** **EndSem Exam: 30 Marks**

Prerequisite Courses: Fundamentals of Electrical Engineering

Course Outcomes: On completion of the course, students will be able to–

	Course Outcomes	**Bloom's Level**
CO1	Decide the Electrical accessories ratings for the control panel.	3-Apply
CO2	Draw the SLD & GA drawing of the panel.	3-Apply
CO3	Design control logic for panel operation	3-Apply

COURSE CONTENTS

Unit I	**Control Panel basics**	**15 hrs.**	**CO1, CO3**

Introduction of electrical wiring system, electrical components specifications and applications, types of cable & wires, Circuit Breakers, neutral Bus Bar, Grounding, and Bonding. Measuring & testing equipment, Ingress protection, safety precautions, tools, etc. Types of Panels.

Unit II	**Design of panels**	**15hrs**	**CO2, CO3**

Design of customised panel: PDB, PCC, MCC, APFC, etc., with SLD, GA drawing, case study,
Occupational Safety and Health, CAT ratings, Electricity rules & regulations, IEC/IS standards

Text Books

1. S. L. Uppal - Electrical Power - Khanna Publishers, Delhi.
2. S. Rao, Testing Commissioning Operation and Maintenance of Electrical Equipment, Khanna Publishers.

Reference Books

1. S. L. Uppal, Electrical Wiring and Costing Estimation, Khanna Publishers, New Delhi.
2. P.S. Pabla –Electric Power Distribution, 5th edition, Tata McGraw-Hill.

Surjit Singh, Electrical Wiring, Estimation, and Costing, DhanpatRai and Company, New Delhi

E Resources

1. http://www.opentextbooks.org.hk/system/files/export/9/9648/pdf/Fundamentals_of_Electrical_Engineering_I_9648.pdf

Useful websites / Video

1. https://studio.youtube.com/channel/UCSXIMvov4_DEbAyvFHrY-PA
2. https://nptel.ac.in/courses/108/105/108105112/

https://www.udemy.com/course/learn-the-basics-of-household-wiring/

Sr. No.	Laboratory Experiments
1	To study various components used in control panels and understand their functions and specifications.
2	To prepare a single-line diagram of a basic motor control panel
3	To design and wire a Direct-On-Line (DOL) starter control circuit.
4	To develop a control and power circuit for the star-delta starting of a three-phase induction motor
5	To perform load calculation for an industrial application and select suitable ratings for panel components
6	To design the physical layout of a control panel and decide busbar arrangement and spacing
7	To understand and apply guidelines for earthing, short-circuit protection, and ingress protection
8	To perform basic functional testing and insulation resistance testing of a control Panel

Guidelines for Laboratory Experiment Conduction

1. The teacher will brief the given experiment to students for its procedure, observations, calculations, and outcome.
2. The apparatus and equipment required for the allotted experiment will be provided by the lab technician.
3. Students will perform the allotted experiment in a group (3-4 students in each group) under the supervision of faculty and a lab technician.
4. After performing the experiment, students will check their readings and calculations from the teacher.
5. After checking, they have to write the conclusion on the final results.
6. A minimum of 4 sets of the experiment should be made ready for the conduction of the experiment in a batch for hardware experiments.

Guidelines for Student's Laboratory Journal

The write-up should include a title, aim and apparatus, circuit or block diagram, waveforms, brief theory, procedure, observations, graphs, calculations, conclusion, and answers to the questions, if any.

Guidelines for Term Work Assessment

Each experiment from the lab journal is assessed for thirty marks based on three rubrics. Rubric R-1 for timely completion, R-2 for understanding, and R-3 for presentation/journal writing, where each rubric carries ten marks.

Final Year B.Tech.
Pattern: 2023 Semester: VI(Electrical Engineering) (EXIT Course)
2306323: Switchgear and Protection

Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Theory:2Hrs./Week **Practical: 2 Hrs./Week**	**TH: 2** **PR: 1**	**InSem Exam: 20Marks** **EndSem Exam: 30Marks** **Term Work: 50 Marks**

Prerequisite Courses: Fundamentals of Electrical Engineering, Power System Analysis

Course Objectives: The objectives of the course are to

- Acquaint students with the construction and working principles of different types of CBs and Relays.
- Explain the different types of faults in the transformer, alternator, and 3-phase induction motor and the various protective schemes related to them.
- Impart knowledge about transmission line and bus bar protection schemes.
- Introduce recent trends and technologies in protection engineering.

Course Outcomes: On completion of the course, students will be able to–

	Course Outcomes	**Bloom's Level**
CO1	Understand the operation and types of circuit breakers and arc interruption techniques.	2-Understand
CO2	Analyze protective relay characteristics and apply fault calculation techniques.	4-Analyze
CO3	Evaluate protection methods for transformers, motors, and generators.	5-Evaluate
CO4	Implement digital relay algorithms for modern power system protection	6-Create

COURSE CONTENTS

Unit I	**Circuit Breaker**	**6 Hrs.**	**CO1, CO2, CO4**

Introduction, fault clearing process, Electric arc formation, Current interruption in AC circuit breaker, high and low resistance principles, arc interruption theories, arc voltage, recovery voltage, derivation and definition of restriking voltage and RRRV, current chopping, interruption of capacitive current, resistance switching, Numerical on RRRV, current chopping and resistance switching, trip circuit, types of circuit breaker, ratings of circuit breaker, Working and constructional features of ACB, SF_6, VCB- advantages, disadvantages and applications. Auto reclosing, introduction to GIS

Unit II	**Protective Relaying**	**6 Hrs.**	**CO1, CO2**

Need for protective system, nature and causes of fault, types of faults, effects of faults, classification of relays, zones of protection, primary and backup protection, essential qualities of protective relaying. Principles of protection - over current, directional over current, differential, and distance.Induction type relay, torque equation in induction type relay, current and time setting in induction relay, Numericals on TSM, PSM and operating time of relay.IEEE and IEC standards and ANSI numbers for protective relays.

Unit III	**Equipment Protection**	**6 Hrs.**	**CO2, CO3**

I. **Power Transformer Protection:** Types of faults in transformer, Percentage differential protection, Restricted E/F protection, incipient faults, protection against over fluxing, protection against inrush current.
II. **3 Phase Induction Motor Protection:** Abnormal conditions and causes of failures, single phasing protection, overload protection, short circuit protection and protection against unbalanced conditions.
III. **Synchronous Generator (Alternator) Protection:** Various faults, abnormal operating conditions- stator faults, longitudinal and transverse percentage differential scheme. Rotor faults- abnormal operating conditions, unbalanced loading, overspeeding, protection against loss of excitation using offset Mho relay, and loss of prime mover.

Unit IV	**Bus Bar and Transmission Line Protection**	**6 Hrs.**	**CO2, CO3**

I. Bus bar layout and protection- differential bus bar protection, selection of CTs, protection during high impedance faults.
II. Over current protection for feeders using directional and non-directional over current relays, Introduction to distance protection, impedance relay, reactance relay, mho relay and Quadrilateral Relays, three stepped distance protection, Effect of arc resistance, and power swing on performance of distance relay.

Unit V	**Digital Relaying**	**6 Hrs.**	**CO2, CO4**

Numerical Relays:- Introduction and block diagram of numerical relay, Sampling theorem, Anti–Aliasing Filter. Block diagram of PMU and its application. Introduction to PLCC, block diagram, advantages, and disadvantages. Introduction to Wide Area Measurement (WAM) system. Realization of numerical relaying algorithm (flowchart, block diagram).

TextBooks

13. S. Rao, ‘Switchgear Protection and Power Systems’, Khanna Publications
14. Y. G. Paithankar, S. R. Bhide, ‘Fundamentals of Power System Protection’, Prentice Hall of India
15. Badri Ram, D. N. Vishwakarma, ‘Power System Protection and Switchgear’, Tata McGraw Hill Publishing Co. Ltd.
16. BhaveshBhalja, R. P. Maheshwari, N. G. Chothani, ‘Protection and Switchgear’, Oxford University Press

Reference Books

11. J. Lewis Blackburn, ‘Protective Relaying – Principles and Applications’, Marcel Dekkar, Inc., New York
12. S. H. Horowitz and A. G. Phadke, ‘Power System Relaying’, John Wiley and Sons Ltd, 2008
13. P M Anderson, ‘Power System Protection’, IEE Press
14. A. G. Phadke, J. S. Thorp, ‘Computer relaying for Power System’, Research Studies Press Ltd, England. (John Willy and Sons Inc. New York)
15. Mason C.R., “Art and Science of Protective Relaying”, Wiley Eastern Limited

NPTEL Course:

13. https://nptel.ac.in/courses/108107167[Power System Protection and Switchgear, IIT Roorkee, Prof. Bhaveshkumar R. Bhalja]
14. https://nptel.ac.in/courses/108105167[Power System Protection, IIT Kharagpur, Prof. Ashok Kumar Pradhan]
15. https://nptel.ac.in/courses/108101039 [Power System Protection, IIT Bombay, Prof. S.A. Soman]

Sr. No.	Laboratory Experiments (minimum 8 experiments)
1	Study of switchgear testing kit
2	Protection of the Transmission line using Impedance relay
3	Study and testing of the fuse, MCB
4	Study and testing of contactors
5	Study and testing of ACB
6	Study and testing of MCCB
7	Study and testing of thermal overload relay for Induction Motor protection.
8	Study and plot the Characteristics of IDMT type Induction over the current relay.
9	Study and parameterization of digital overcurrent relay.
10	Percentage differential protection of transformer (Merz Price Protection).
11	Protection of alternators.
12	Study and testing of Bus Bar protection.

Guidelines for Laboratory Experiment Conduction

1. The teacher will brief the given experiment to students for its procedure, observations, calculations, and outcome.
2. The apparatus and equipment required for the allotted experiment will be provided by the lab technician.
3. Students will perform the allotted experiment in a group (3-4 students in each group) under the supervision of faculty and a lab technician.
4. After performing the experiment, students will check their readings and calculations from the teacher.
5. After checking, they have to write the conclusion on the final results.
6. A minimum of 4 sets of the experiment should be made ready for the conduction of the experiment in a batch for hardware experiments.

Guidelines for Student's Laboratory Journal

The write-up should include a title, aim and apparatus, circuit or block diagram, waveforms, brief theory, procedure, observations, graphs, calculations, conclusion, and answers to the questions, if any.

Guidelines for Term Work Assessment

Each experiment from the lab journal is assessed for thirty marks based on three rubrics. Rubric R-1 for timely completion, R-2 for understanding, and R-3 for presentation/journal writing, where each rubric carries ten marks.