DR. BABASAHEB AMBEDKAR TECHNOLOGICAL UNIVERSITY, LONERE.

Dr. Babasaheb Ambedkar Technological University
(Established as a University of Technology in the State of Maharashtra)
(Under Maharashtra Act No. XXIX of 2014)
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National Education Policy (NEP) 2020 for the session 2026-27

For

Third Year B. Tech. Electrical Engineering

With effect from the Academic Year 2026-2027

DR. BABASAHEB AMBEDKAR TECHNOLOGICAL UNIVERSITY, LONERE.

B. Tech Electrical Engineering

A. Program Educational Objectives (PEOs)

Graduates will able to–

1. To equip graduates with a strong foundation in engineering sciences and Electrical Engineering fundamentals to become effective collaborators, researchers and real-time problem solver with technical competencies.
2. Perceive the limitation and impact of engineering solutions in social, legal, environmental, economic and multidisciplinary contexts.
3. Excel in Industry/technical profession, higher studies, and entrepreneurship exhibiting global competitiveness.

B. Program Outcomes (POs)

Engineering Graduate will be able to –

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis, and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the

consequent responsibilities relevant to the professional engineering practice.

7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. **Ethics:** Apply ethical principles and commitment to professional ethics and responsibilities and norms of engineering practice.

9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverseteams, and in multidisciplinary settings.

10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, making effective presentations, and give and receive clear instructions.

11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering andmanagement principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. **Life-long learning:** Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

C. Program Specific Outcomes (PSO)

Electrical Engineering graduates will specifically be able to do in their field.

1. Demonstrate the ability to apply fundamental knowledge of mathematics, science and engineering to identify, formulate, analyze, investigate, and design complex problems in the field of electrical engineering.

2. Demonstrate ability to apply the appropriate techniques and modern engineering tools to manage and solve complex electrical engineering projects, adapt in multi-disciplinary environments, and engage in lifelong learning.

3. Able to propose & implement engineering solutions in the context of the environment, society, economy, and professional ethics and have good communication skills

B. Tech Third Year Electrical Engineering

SEMESTER V											
Sr. No.	**Course Code**	**Course Title**	**Teaching Scheme**			**Marking Scheme**			**Total Marks**	**CR**	**Category**
			L	**T**	**P**	**CA**	**MSE**	**ESE**			
1	**26UD1293PC501**	Power System Analysis	3			20	20	60	100	**3**	**PCC**
2	**26UD1293PC502**	Electrical Machine II	3			20	20	60	100	**3**	**PCC**
3	**26UD1293PC503**	Power Electronics	3			20	20	60	100	**3**	**PCC**
4	**26UD1293PE504**	Program Elective-I	2			20	20	60	100	**2**	**PEC**
5	**26UD1293OE505**	**Open Elective III***	2			20	20	60	100	**2**	**OE**
6	**26UDXXXXMD506**	**MDM Bucket***	3			20	20	60	100	**3**	**MDM**
7	**26UD1293PCL507**	Power System Analysis II Lab			2	60		40	100	**1**	**PCC**
8	**26UD1293PCL508**	Electrical Machine II Lab			2	60		40	100	**1**	**PCC**
9	**26UD1293PCL509**	Power Electronics Lab			2	60		40	100	**1**	**PCC**
10	**26UD1293VE510**	Mini Project-II			2	60		40	100	**1**	**VSEM**
		Total	**16**	**1**	**8**				**1000**	**20**	

NOTE: * Refer to Multidisciplinary Minor Bucket
Refer to *Open Elective III* **Bucket ***

BSC/ESC: *Basic Science Course/ Engineering Science Course,* ***PCC:*** *Programme Core Course* ***PEC:*** *Programme Elective Course,* ***Multidisciplinary (OE):*** *Open Elective Other than particular programme,* ***VSEC:*** *Vocational and Skill Enhancement Course,* ***HSSM:*** *Humanities Social Science and Management,* ***IKS:*** *Indian Knowledge System, HSSM- VEC: Value Education Course,* ***CCA:*** *Co-curricular & Extracurricular Activities* ***NPTEL Course: Online NPTEL Course***

Program Elective-I	
26UD1293PE504A	Signals And System
26UD1293PE504B	Electromagnetic Field Theory
26UD1293PE504C	Smart Grid Technology
26UD1293PE504D	Power Plant Engineering
26UD1293PE504E	Microprocessor and Microcontroller

SEMESTER VI

Sr. No.	Course Code	Course Title	Teaching Scheme			Marking Scheme			Total Marks	CR	Category
			L	T	P	CA	MSE	ESE			
1	**26UD1293PC601**	Switchgear and Protection	3			20	20	60	100	**3**	**PCC**
2	**26UD1293PC602**	Electrical Machine Design	3			20	20	60	100	**3**	**PCC**
3	**26UD1293PC603**	Control System	3			20	20	60	100	**3**	**PCC**
4	**26UD1293PE604**	Program Elective-II	3			20	20	60	100	**3**	**PEC**
5	**26UD1293PE605**	Program Elective-III	3			20	20	60	100	**3**	**PEC**
6	**26UDXXXXMD606**	**MDM Bucket***	2			20	20	60	100	**2**	**MDM**
7	**26UD1293PCL607**	Switchgear and Protection Lab			2	60		40	100	**1**	**PCC**
8	**26UD1293PCL608**	Electrical Machine Design Lab			2	60		40	100	**1**	**PCC**
9	**26UD1293PCL609**	Control System Lab			2	60		40	100	**1**	**PCC**
10	**26UD1293VE610**	Electrical Maintenance and Commissioning of Electrical Equipment	2			20	20	60	100	**2**	**VSEM**
11	**26UD1293VE611**	Seminar			2	50			50	**AU**	**VSEM**
		Total	**19**		**8**				**1050**	**22**	

NOTE: * Refer to Multidisciplinary Minor Bucket

Program Elective-II	
26UD1293PE604A	Electrical Utilization
26UD1293PE604B	Transients in Electrical Power System
26UD1293PE604C	Electrical Vehicle System
26UD1293PE604D	Embedded Systems

Program Elective-III	
26UD1293PE605A	Flexible AC Transmission System
26UD1293PE605B	Power Quality Issue
26UD1293PE605C	Industrial Automation & Control
26UD1293PE605D	Robotics and Automation Engineering

Multidisciplinary minors Subjects

For the Electrical Engineering Department (MDM Subjects Electrical)

For other than Electrical engineering Student for Multidisciplinary minors Degree*

Semester	Category	Subject Code	Subject Name	Total Credit
SEM-III	Foundation Courses	25UD1293MD306	Electrical and Electronics Measurements	**2**
SEM-IV	Core Electrical Engineering Courses	25UD1293MD406	Electrical Machine	**3**
SEM-V	Core Electrical Engineering Courses	25DU1293MD506	Power System	**3**
SEM-VI	Core Electrical Engineering Courses	25DU1293MD606	Switchgear And Protection	**3**
SEM-VII	Electives/Specialization Courses	25UD1293MD706	High Voltage Engineering	**2**
SEM-VIII	Project/Research Work	25UD1293MD806	Project/Research Work	**2**
Total credits required to complete a Minor Degree in Electrical Engineering				**15**

Semester V		
Power System Analysis		
Teaching Scheme Lectures Theory: 03Hr / Week Credit:03	**Examination Scheme** Internal Assessment: 20 Marks Mid-Sem Exam: 20 Marks End Sem Exam: 60 Marks	

Course Objective:

1. Understand and apply power system modeling principles, including complex power flow and per-unit representation.
2. Analyze load flow studies using iterative techniques like Gauss-Seidel and Newton Raphson methods.
3. Conduct fault analysis in power systems, covering symmetrical and unsymmetrical fault conditions.
4. Evaluate power system security, including contingency analysis and power quality management techniques.
5. To analyse symmetrical and unsymmetrical faults using symmetrical components and evaluate grid security, contingency planning, and power quality standards.

Course Outcome:

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

CO1. Able to draw impedance diagrams for a power system network and to understand per unit quantities.
CO2. Able to form a Y bus and Z bus for a power system network.
CO3. Able to understand the load flow solution of a power system using different methods.
CO4. Able to find fault currents for all types faults to provide data for the design of protective devices.
CO5. Able to find the sequence components of currents for unbalanced power system network.

Unit	Contents	Hrs.
1	**Modeling of Power System:** Complex power flow, balanced and reactance diagrams of a power system, per unit system per unit representation of transformers, synchronous machines, representation of loads. Graph theory and its applications for formation of primitive network and Z and Y matrices, incidence matrices, Ybus and Z-bus matrices	**7**
2	**Load Flow Studies:** Introduction, network model formulation, formation of Y-bus by singular transformation, load flow problem, Iterative methods of load flow such as Gauss Gauss-Seidel, Newton-Raphson method, decoupled load flow and fast decoupled load flow, Automatic Generation control.	**7**
3	**Symmetrical Fault Analysis:** Transients on a transmission line, short circuit of a synchronous machine on no load and on load. Short circuit current computation on no load and on load, selection of circuit breakers, Z-bus formulation, algorithm of short circuit studies	**6**

4	**Symmetrical Components:** Fundamentals of symmetrical components, sequence impedance and sequence network of star connected loads, transmission lines, synchronous machines and transformer sequence network of a loaded generator. **Unsymmetrical Faults Analysis:** single line to ground (l-g), Line to line (L-L), double line to ground (L-L-G) faults analysis of above faults using bus impedance matrix, bus voltage and line current during faults. Open conductor faults	**7**
5	**Security Analysis:** Basic Concepts, Security analysis, Load Dispatch centre, Contingency Analysis, preventive and emergency control, Electrical Power Quality, causes, affects, and mitigation methods.	**7**
	References: 1. "Power System Analysis", T.K. Nagsarkar, M.S. Sukhiya. (OXFERD U. P.), 3rd Edition, 2017 2. I.J. Nagrath & D.P. Kothari, "Modern System Analysis", Tata McGrawHill , 5th Edition, 2019 3. Stevenson W.D. and Grainger J.J. "Power System Analysis" McGrawHill , **1st Edition, 1994** 4. A.R. Bergen and Vijay Vittal, Power Systems Analysis, Pearson Education Asia, 2001. 5. Stagg W.D. & EI-AbiadA. H. "Computer Method in Power System Analysis", McGraw- Hill , 1968 6. H.Saadat "Power System analysis", McGraw- Hill , **3rd Edition, 2010** 7. Elgred O.I. electrical Energy System Theory," McGraw-Hill. **2nd Edition, 1982**	

Electrical Machine II

Teaching Scheme	**Examination Scheme**
Lectures Theory: 03 Hr / Week Credit:03	Internal Assessment: 20 Marks Mid-Sem Exam: 20 Marks End Sem Exam: 60 Marks

Course Objectives:

1. To provide an understanding of the construction, principle of operation, and performance characteristics of single-phase motors.
2. To equip students with detailed knowledge of three-phase induction motors.
3. To familiarize students with various starting methods and testing techniques for induction motors, including the determination of equivalent circuit parameters and performance pre-determination using circle diagrams.
4. To explain the constructional features, working principles, and performance evaluation of synchronous generators.
5. To develop an in-depth understanding of the theory of operation of synchronous motors, including phasor diagrams, V-curves, methods of starting, and practical applications.

Course Outcome:

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

CO1. Analyze the construction and operation of single-phase motors based on the double revolving field theory.

CO2. Explain the working principle and classification of three-phase induction motors, derive torque equations, analyze torque-slip characteristics.

CO3. Perform testing and analysis of induction motors, including no-load and blocked rotor tests, and use equivalent circuits and circle diagrams for pre-determination of performance.

CO4. Understand the constructional details and working principles of synchronous generators.

CO5. Develop phasor diagrams and understand the performance of synchronous motors under varying excitation, analyze V and inverted V curves.

Unit	Contents	Hrs.
1	**Single-phase motors:** Introduction to single-phase motors, construction, principle of operation based on the double revolving field theory, equivalent circuit analysis, starting methods (split-phase, capacitor start, shaded pole), torque-speed characteristics, performance analysis, different types of single-phase motors, and applications; including detailed explanations of each aspect and calculations related to motor parameters and performance under various conditions	**7**
2	**Three Phase Induction Motors:** Introduction: Constructional details, classification, principle of operation, production of rotating magnetic field and rating of induction motors. Analysis of Induction Motors: Phasor diagram, equivalent circuit, Torque equations for starting, full load and maximum operating conditions, Condition for maximum-output, slip for maximum-output, Torque slip characteristics, losses & efficiency and applications.	**7**

3	**Starters and Testing of Induction Motors:** Auto transformer, star delta and rotor resistance starters. No load and blocked rotor tests-determination of equivalent circuit parameters, Pre-determination of performance from equivalent circuits and circle diagram. Concepts of single phasing.	**6**
4	**Synchronous Generator:** Constructional features, classification, ratings, winding factors, production of emf, harmonics, emf equation, armature reaction, Synchronous reactance, phasor diagrams for various operating conditions, load characteristics, open circuit and short circuit tests. Methods of pre- determination of regulation-Synchronous impedance, ampere-turn. Two reaction theory–analysis and its application for the pre-determination of regulation of salient pole alternator, phasor diagrams. Slip test, power-angle characteristics, synchronization and synchronizing power. Parallel operation and load sharing–operation on infinite bus-bar, typical applications.	**6**
5	**Synchronous Motor:** Theory of operation–phasor diagrams for various operating conditions, variation of current and power factor with excitation. Hunting and its suppression, determination and pre-determination of V and inverted V curves, method of starting. Problems on emf equation, regulation calculations of salient and non-salient pole synchronous generators, parallel operation and load sharing, losses and efficiency of salient and non-salient pole synchronous motors.	**6**
	Text Books: ***1.*** Electrical Machinery, Theory: Performance & Applications Dr. P. S. Bimbhra, Khanna Publishers, 2021. ***2.*** Nagarath & D.P.Kothari: Electrical Machines, TMH Publishers, 5thEdition, 2017**.** 3. A Textbook of Electrical Technology, Volume II by B.L. Theraja and A.K. Theraja (S. Chand) 25th Multicolor Edition, 2020 ***Reference Books:*** 1. Electric Machines, Charles A. Gross, CRC Press, 2007. 2. Electric Machinery by A.E. Fitzgerald, Charles Kingsley Jr., and Stephen D. Umans (McGraw-Hill), 7th Edition, 2013 3. Electric Machinery Fundamentals by Stephen J. Chapman (McGraw-Hill), 6th Edition, 2009 4. Electric Machinery, A.E. Fitzgerald, Charles Kingsley, Stephen D. Umans, Sixth Edition TMH, 2009. 5. Electric Machines, Charbs. I.Hubert, SecondEdition–Pearson, 2003. 6. Electric Machinery, Stephen. J.Chapman, McGrawHillInternationalEdition,2005. 7. Alternating Current Machines, M.G.Say, Wiley, 1983. 8. Theory of Alternating Current Machine, Alexander. S. Langsdorf, Tata McGrawHill, Second Edition, 2009. 9. Introduction to Modern Analysis of Electric Machines and DrivesThomas C. Krause; Paul C. Krause, Wiley-IEEE Press, **2nd Edition, 2013**	

Power Electronics	
Teaching Scheme Lectures Theory: 03 Hr / Week Credit:03	**Examination Scheme** Internal Assessment: 20 Marks Mid-Sem Exam: 20 Marks End Sem Exam: 60 Marks

Course Objective:

6. To understand the working principles and characteristics of power semiconductor devices such as diodes, thyristors, IGBTs, and MOSFETs.
7. To analyse and design-controlled rectifiers for single-phase and three-phase systems, including their performance with resistive (R) and inductive (RL) loads.
8. To study the operation and control strategies of DC-DC converters (choppers) and analyse their steady-state performance, including buck, boost, and buck-boost configurations
9. To explore the working principles of inverters and their control techniques, including PWM methods, and analyse their applications in single-phase and three-phase systems.
10. To examine the operation of AC voltage controllers and cycloconverters and understand their principles, types, and applications in power control and frequency conversion.

Course Outcome:

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

CO6. Understand the requirements of an ideal switch and the characteristics of important power semiconductor switches.
CO7. Analyze power electronic switch-based rectifiers, converters and inverters.
CO8. Select circuit elements required for a Power Electronic system.
CO9. Design a power electronic system for a given application.
CO10. understand their principles, types, and applications in power control and frequency conversion.

Unit	Contents	Hrs.
1	**Power Semiconductor Switches:** Characteristics of ideal vs. practical switches; static and dynamic behaviors of Power Diodes, SCRs, Power MOSFETs, and IGBTs. Gate triggering, turn-off commutation concepts, optocoupler/pulse-transformer isolation, and turn-on (di/dt) and turn-off (dv/dt) snubber protection.	7
2	**Phase-Controlled Rectifiers:** Line-frequency controlled rectifiers using SCRs. Analysis of single-phase half-wave, semi-converter, and fully-controlled bridge converters with continuous current. Covers performance metrics (THD, Power Factor, Displacement Factor), three-phase fully-controlled bridges, and source inductance overlap angle (μ) effects.	7
3	**DC-DC Choppers:** Principles of chopper operation and control strategies (PWM and Current Limit Control). Quadrant configurations (Classes A–E); steady-state continuous conduction mode (CCM) analysis of Buck, Boost, and Buck-Boost topologies including voltage ripple. Includes discontinuous conduction mode (DCM) and DC motor drive applications.	6

4	**Inverters & Grid Integration:** Single-phase half/full-bridge inverters under square-wave operation; modulation techniques (single-pulse, multi-pulse, SPWM) and unipolar/bipolar switching. Three-phase inverters (180^0 conduction mode, SPWM, third-harmonic injection). Single-phase grid-tied systems featuring hysteresis current control and synchronous link voltage source inverter power flow regulation.	**7**
5	**AC-AC Controllers & Cycloconverters:** Principles of Phase Control and Integral Cycle control for single-phase AC voltage regulators with R and RL loads; multi-stage transformer sequence control. Principles of single-phase and three-phase cycloconverter topologies for direct frequency conversion.	**7**
	References: 1. L Umanand, Power Electronics: Essentials and Applications, Wiley India Pvt. Limited, 2009 2. Robert W. Erickson, Dragan Maksimović, Fundamental of Power Electronics, Springer Link, Third edition, 3rd Edition, 2020 3. Ned Mohan, Power Electronics., John Wiley and Sons, 2nd edition, 1995. 4. Rashid, Power Electronics, Circuits Devices and Applications, Pearson Education, 3rd edition, 2004. 5. G.K.Dubey, Thyristorised Power Controllers, Wiley Eastern Ltd, 1993. 6. Dewan & Straughen, Power Semiconductor Circuits, John Wiley & Sons, 1975. 7. Cyril W Lander, Power Electronics, Mc Graw Hill, 3rd edition, 1993. 8. P S Bimbhra, Power Electronics, Khanna Publication, 5th Edition, 2015	

Program Elective-I

(A) Signals And System

Teaching Scheme	**Examination Scheme**
Lectures Theory: 02 Hr / Week Credit:02	Internal Assessment: 20 Marks Mid-Sem Exam: 20 Marks End Sem Exam: 60 Marks

Course Objective:

1. Understand the fundamental concepts of signals and systems
2. Learn the properties of Linear Time-Invariant (LTI) systems
3. Apply mathematical techniques for signal analysis
4. Develop skills in time-domain and frequency-domain analysis
5. Enhance problem-solving abilities using computational tools

Course Outcome:

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

CO1. Comprehend signal classification and operations
CO2. Analyze and interpret LTI systems
CO3. Apply convolution in time-domain analysis
CO4. Utilize Laplace and Z-transforms for system analysis
CO5. Understand and implement Fourier series and Fourier transforms

Unit	Contents	Hrs.
1	**Elements of Signal Space Theory:** Objective and overview, Signals – Definition, Signals and their representation, classification of signals, singularity functions – Impulse, step, ramp functions, representation of signals with singularity functions, exponential functions, Basic operations on Signal.	**7**
2	**Classification of System** Definition of system, CT and DT system, basic properties of system –linear time invariant system and properties, LTI system: Causality, stability, step response, impulse response.	**6**
3	**Convolution** Convolution sum, convolution integral and their evaluation; Time-domain representation and analysis of LTI systems based on convolution and differential equations. Convolution for CT & DT signals and systems; Necessity of representations of Signals & Systems in Time- and Transformed-domains	**6**
4	**Transform domain considerations** Laplace transforms and inverse Laplace transforms; Applications of transforms to discrete and continuous systems-analysis; Transfer function, block diagram representation. Z-Transforms: ROC, properties of Z-Transforms and Inverse Z-Transforms, Causality and stability	**6**
5	**Fourier series and Fourier Transform** Sampling theorem, Discrete Fourier transform (DFT), estimating Fourier transform using DFT Analysis of discrete time signal: sampling of CT signals and aliasing, DTFT and properties.	**6**

	Reference Books 01. Signals and Linear Systems, Gabel R.A. and Robert R.A, John Wiley and Sons, New York, 2nd Edition, 1998. 02. Systems and Signal Analysis, C.T. Chen, Oxford University Press, New Delhi, 3rd Edition, 2010. 03. Signals And Systems - 4th Edn, P. Ramesh Babu · 2010 04. Probabilistic Methods of Signals and System Analysis, Cooper G.R and McGillem C.D, Oxford University Press, Cambridge. 3th Edition, 1999 05. Signals and Systems, Ziemer R.E., Tranter W.H., and Fannin D.R., Pearson Education Asia, 4th Edition, 2014 06. Signals and Systems, Alan V. Oppenheim, Alan S. Willsky, with S. Hamid Nawab, Pearson Education. 2nd Edition, 1997 07. Signals and Systems: Continuous and Discrete, Rodger E. Ziemer, William H. Tranter, D. Ronald Fannin, Pearson Education. 4th Edition, 2014 08. Singapore "Signals and Systems" by Alan V. Oppenheim, Alan S. Willsky, and with S. Hamid Nawab, Prentice Hall, New Delhi, 2nd Edition, 1997 09. "Signals and Systems" by Simon Haykin and Barry Van Veen, 2nd Edition, 2003 10. "Signals and Systems: Continuous and Discrete" by Michael J. Roberts, 2nd Edition, 2016 11. "Principles of Linear Systems and Signals" by B.P. Lathi, 2nd Edition, 2005	

Program Elective-I	
(B) Electromagnetic Field Theory	
Teaching Scheme Practical: 2 Hr / Week Credit:02	**Examination Scheme** Internal Assessment: 20 Marks Mid-Sem Exam: 20 Marks End Sem Exam: 60 Marks

Course Objective:

1. To introduce the concepts of vector calculus, including gradient, divergence, curl, and their applications in different coordinate systems (rectangular, cylindrical, and spherical).
2. To study electrostatic fields, including Coulomb's law, electric potential, Gauss's law, and their applications to various charge distributions and dielectric materials.
3. To explore magnetostatics, including magnetic fields, Lorentz force, Biot-Savart's law, Ampere's law, and the properties of magnetic materials and boundary conditions.
4. To understand the dynamics of electromagnetic fields, including Faraday's law, induced EMF, Maxwell's equations, and their relationship to circuit theory.
5. To analyze electromagnetic wave equations, their propagation, and the properties of waves in different media, including skin depth and Poynting's theorem.

Course Outcome:

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

CO1: Apply the spatial variations of physical quantities using various co-ordinate systems.
CO2: Apply basic laws of electrostatics to determine force and electric field intensity.
CO3: Evaluate magnetic vector quantities, inductance and energy densities of various cables.
CO4: Analyze the electromagnetic fields from the basics of Maxwell's equations.
CO5: Analyze the electromagnetic wave propagation in different media using Poynting vector and theorem

1	**VECTOR CALCULUS:** Sources and effects of electromagnetic fields – Scalar and Vector fields – Vector Calculus – Gradient, Divergence and Curl – Divergence theorem - Stoke's theorem - Different Co-ordinate Systems: Rectangular, Cylindrical and Spherical – Relationship between Co-ordinate systems.	**7**
2	**ELECTROSTATICS:** Coulomb's Law - Electric field intensity (E) - Field due to point and continuous charges – Electric field due to finite line charge, circular disc, two concentric shells and coaxial cylinders - Electric flux density (D) - Gauss's law and its applications - Electrical potential - Electric field in dielectric and equipotential plots - Electric Dipole, Electric field in multiple dielectrics - Boundary conditions between dielectric media, Poisson's and Laplace's equations – Capacitance -Energy density.	**7**
3	**MAGNETOSTATICS:** Lorentz Law of force, magnetic field intensity (H) - Biot-Savart's Law - Ampere's Law - Magnetic field intensity due to straight conductors, infinite sheet of current, at the centre of the toroid, along the axis of the circular loop	**7**

	and solenoid - Magnetic flux density (B) – Magnetic materials - Magnetization - Boundary conditions – Magnetic Scalar and vectorpotential - Magnetic force - Torque - Inductance - Energy densit.	
4	ELECTRODYNAMIC FIELDS: Faraday's laws, Induced EMF - Transformer and Motional EMF, Maxwell's Equations (differential and integral forms) – Conduction and Displacement Current –Ohm's law in point form - Relation between field theory and circuit theory.	**6**
5	ELECTROMAGNETIC WAVES: Electro Magnetic Wave equations - Wave parameters; velocity, intrinsic impedance, propagation constant – Uniform plane wave and its properties - Waves in free space, lossy and lossless dielectrics, conductors - Skin depth, Poynting vector and Poynting Theorem.	**6**
	Text Books: 1. Mathew N. O. Sadiku, Elements of Electromagnetics, Oxford University Press, Sixth Edition, 2014. 2. William. H. Hayt, Engineering Electromagnetics, Tata McGraw Hill, Seventh Edition,2012. **References:** 1. K.A.Gangadhar, Field Theory, Khanna Publishers, New Delhi, Sixteenth Edition, 2015. 2. S.P. Ghosh and LipikaDatta, Electromagnetic Field Theory, Tata McGraw Hill Educational Private Limited New Delhi, First Edition, 2012. 3. Joseph.A.Edminister, Thoery and problems of Electromagnetics, Schaum Series, Tata McGraw Hill, Second Edition, 1993. 4. vid J.Griffiths, Introduction to Electrodymanics, Pearson Education, Fourth Edition, 2014.	

Program Elective-I	
(C) Smart Grid Technology	
Teaching Scheme Practical: 02 Hr / Week Credit:02	**Examination Scheme** Internal Assessment: 20 MarksMid-Sem Exam: 20 Marks End Sem Exam: 60 Marks

Course Objective:

1. Understand the fundamentals of power systems and the evolution of the electric grid towards a smarter infrastructure.
2. Gain knowledge about the key components, technologies, and architectures that enable the functioning of a smart grid.
3. Develop an understanding of the various tools and techniques used in the planning, operation, and control of smart grids.
4. Explore the role of distributed generation technologies, including renewable energy sources, in the modern power system.
5. Learn about the importance of communication technologies, IoT, and their applications in the context of smart grids and smart cities.

Course Outcome:

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

CO1: Students will be able to explain the basic concepts of power systems and the rationale behind the development of smart grids.

CO2: Students will be able to analyze different smart grid architectures, identify key components, and understand their interactions.

CO3: Students will be able to apply computational and intelligent techniques for optimizing power system operations and solving smart grid challenges.

CO4: Students will be able to evaluate the potential and challenges of integrating distributed generation sources, including renewable energy, into the grid.

CO5: Students will be able to understand the role of communication technologies, IoT, and cyber security in the successful implementation of smart grids and smart cities.

Unit	Contents	Hrs.
1	**Introduction to Smart Grid**: Basics of power systems, definition of smart grid, need for smart grid, smart grid domain, enablers of smart grid, smart grid priority areas, regulatory challenges, smart-grid activities in India.	6
2	**Smart Grid Architecture:** Smart grid architecture, standards-policies, smart-grid control layer and elements, network architectures, IP-based systems, power line communications, supervisory control and data acquisition system, advanced metering infrastructure. The fundamental components of Smart Grid designs, Transmission Automation, Distribution Automation, Renewable Integration.	6
3	**Tools and Techniques for Smart Grid**: Computational Techniques – Static and Dynamic Optimization Techniques for power applications such as Economic load dispatch – Computational	7

	Intelligence Techniques – Evolutionary Algorithms in power system – Artificial Intelligence techniques and applications in power system.	
4	**Distribution Generation Technologies**: Introduction to Distribution Energy Sources, Renewable Energy Technologies – Microgrids – Storage Technologies –Electric Vehicles and plug – in hybrids – Environmental impact and Climate Change – Economic Issues.	6
5	**Communication Technologies and Smart-cities:** Introduction to Communication Technology, Two Way Digital Communications Paradigm, Synchro- Phasor Measurement Units (PMUs) – Wide Area Measurement Systems (WAMS)- Introduction to Internet of things (IoT)- Applications of IoT in Smart Grid. Smart city pilot projects, essential elements of smart cities, active distribution networks, microgrids, distribution system automation, Reliability and resiliency studies, decentralized operation of power network.	7
	References: 1. James Momoh, Smart Grid Fundamentals of Design and Analysis, Wiley, 2012 2. Ali Keyhani, “Design of smart power grid renewable energy systems”, Wiley IEEE, 3 rd Edition, 2019 3. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Smart Grid: Technology and Applications, Wiley 2012. 4. Jean Claude Sabonnadiere, Nouredine Hadjsaid, Smart Grids, Wiley ISTE 2012. 5. Smart Grids, Infrastructure, Technology and Solutions, S. Borlase, CRC Press, 2013, 1st Edition. 6. Renewable and Efficient Electric Power System, G. Masters, Wiley–IEEE Press, 2013, 2nd Edition.	

<table>
<tr><th colspan="3">Program Elective-I</th></tr>
<tr><th colspan="3">(D) Power Plant Engineering</th></tr>
<tr><td colspan="2">Teaching Scheme
Lectures Theory: 02 Hr / Week
Credit:03</td><td>Examination Scheme
Internal Assessment: 20 Marks
Mid-Sem Exam: 20 Marks
End Sem Exam: 60 Marks</td></tr>
<tr><td colspan="3">Course Objective:
1. To understand the basic concepts of power generation
2. To analyze the operation and layout of thermal, hydro, and nuclear power plants
3. To explore renewable energy sources and technologies
4. To understand economic considerations in power systems
5. To understand the integration and control of power plants in a grid system</td></tr>
<tr><td colspan="3">Course Outcome:
After completion of this course, students will be able to:
1. Ability to classify and describe various power plants
2. Proficiency in the design and operation of power plants
3. Knowledge of renewable energy systems
4. Ability to evaluate economic aspects of power plant operation
5. Skill in grid integration and system control</td></tr>
<tr><th>Unit</th><th>Contents</th><th>Hrs.</th></tr>
<tr><td>1</td><td>Introduction to Power Generation and Economic Considerations:
Introduction to Power Generation form the Conventional energy sources And non-conventional energy sources: Thermal, hydro, nuclear, and gas power plants, Functioning and control of power plants, Types of prime movers, generators, and excitation systems. Solar, wind, geothermal, ocean-thermal, tidal, wave, and MHD (Magneto-Hydro-Dynamic) power generation. Economic Considerations in Power Systems Load and energy survey, load duration curve, Plant factor and plant economics.</td><td>6</td></tr>
<tr><td>2</td><td>Thermal and Hydro Power Plants:
Thermal Power Plants Site selection, plant layout, operational circuits of the power plant Turbo-alternators, types of boilers, steam turbines, controls, and auxiliaries. (Numerical)

Hydro Power Plants Site selection, classification, and elements of hydroelectric power plants. Water turbines, governor action, hydroelectric generators, and plant layout. Pumped storage plants (Numerical)</td><td>6</td></tr>
<tr><td>3</td><td>Nuclear and Diesel/Gas Power Plants:
Nuclear Power Plants Selection of site, nuclear reaction, fission process, and chain reaction. Nuclear reactor working, classifications, control, shielding, and waste disposal.

Diesel and Gas Power Plants Advantages and limitations of diesel and gas plants. Types of diesel plants, general layout, and applications. Components of a gas power plant, gas turbines, fuels, materials, working, and applications.</td><td>6</td></tr>
</table>

4	**Renewable Power Plants:** **Solar Power Generation** Photovoltaic and solar thermal generation, solar concentrators. **Wind Power Generation** Types of windmills, wind generators. **Other Renewable Power Sources** Tidal, biomass, geothermal, magneto-hydro-dynamic power generation. Micro-hydel power plants and fuel cells.	**6**
5	**Combined Operation of Power Plants**: Plant Selection and Design Selection criteria for power plants, size, and number of generator units. Operation and Load Sharing Parallel operation of various generating sources. Load sharing, interconnected systems, and grid concepts. Power Exchange and Major Equipment Real and reactive power exchange among interconnected systems. Key electrical equipment in power plants. DC systems, station control, switchyard, and control room. Economic Consideration, Types of costs in power plants, tariff structure, and consumers.	**6**
	Text/Reference Books: 1. *Generation, Distribution, and Utilization of Electrical Energy*, by **Wadhwa, C.L.**, New Age International Publishers, 3rd Edition, 2010. 2. *A Course in Power Systems*, by **J.B. Gupta**, S.K. Kataria and Sons, Reprint 2010-2011. 3. *Power Plant Technology*, by **M. M. El-Wakil**, McGraw-Hill, Digitized on Dec 2000. 4. **"Power Plant Engineering" by P.K. Nag ,**Tata McGraw-Hill Education,3rd Edition (2012) 5. **"Principles of Power System" by V.K. Mehta and Rohit Mehta,** S. Chand & Company,2014 **6. "Power Plant Engineering" by G.R. Nagpal,** KHANNA PUBLISHERS, 2012	

Program Elective-I		
(E) Microprocessor and Microcontroller		
Teaching Scheme Lectures Theory: 02Hr / Week Credit:03		**Examination Scheme** Internal Assessment: 20 MarksMid-Sem Exam: 20 Marks End Sem Exam: 60 Marks

Course Objective:

1. Analyze the internal architecture and functional organization of 8085 and 8051 processors.
2. Develop efficient Assembly language programs for computational and control tasks.
3. Interface memory and peripheral devices using various I/O and data transfer schemes.
4. Implement interrupt-driven systems and DMA controllers for optimized hardware communication.
5. Design embedded applications by utilizing on-chip timers, serial ports, and parallel I/O.

Course Outcome:

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

CO1. Describe the functional block diagram and operational characteristics of the 8085 microprocessor and 8051 microcontroller.

CO2. Develop and implement Assembly language programs to solve computational and logical problems.

CO3. Design hardware interface circuits for memory, keyboards, and display units using appropriate I/O mapping techniques.

CO4. Analyze and implement interrupt service routines and DMA data transfer schemes for efficient system performance.

CO5. Configure and utilize on-chip peripherals of the 8051, including timers, serial ports, and parallel I/O, for specific real-world applications.

Unit	Contents	Hrs.
1	**Architecture of 6065 Microprocessor and Programming**: Functional Block Diagram, Registers, ALU, Bus systems, Timing and control signals, Machine cycles and timing diagrams. Instruction formats, Addressing modes, Instruction set, Need for Assembly language, Development of Assembly language programs	**6**
2	**Interfacing**: Memory Interfacing: Interface requirements, Address space partitioning, Buffering of Buses, timing constraints, Memory control signals, Read and write cycles, interfacing SRAM, EPROM and DRAM sections. I/O Interfacing: Memory mapped I/O Scheme, I/O mapped I/O scheme, Input and Output cycles, Simple I/O ports, Programmable peripheral interface (6255). Data transfer schemes: Programmable data transfer, DMA data transfer, Synchronous, Asynchronous and interrupt driven data transfer schemes, Interfacing, Simple keyboards and LED displays.	**6**
3	**Interrupts and DMA**: Interrupt feature, Need for interrupts, Characteristics of Interrupts, Types of Interrupts, Interrupt structure, Methods of servicing interrupts, Development of Interrupt service subroutines, Multiple interrupt request and their handling, need for direct memory access, Devices for Handling DMA, Programmable DMA controller 6237, Applications of microprocessors.	**6**

4	**Intel 6051 Microcontroller** : Architecture of 6051, Memory Organization, Addressing modes, Instruction set, Boolean processing, Simple programs	6
5	**6051 Peripheral Functions** : 6051 interrupt structures, Timer and serial functions, parallel port features : Modes of operation, Power control, features, Interfacing of 6051, Typical applications, MCS 51 family features	6
	Text/Reference Books: 1.Goankar, R.S., "Microprocessor Architecture Programming and Applications with the 6065/6060A", 3rd Edition, Penram International Publishing House, 1997. 2. Singh. I.P., "Microprocessor Systems", Module 9: Microcontrollers and their Applications", IMPACT Learning Material Series IIT, New Delhi, 1997. 3. Douglas, V. Hall. "Microprocessor and Interfacing Programming and Hardware", 2ndEdition, McGraw Hill Inc., 1992. 4. Kenneth, L. Short., "Microprocessors and Programmed Logic", Prentice Hall of India, 2nd Edition, 1967.	

24U1293PCL409	**Power System Analysis Lab**
Teaching Scheme Practical: 02 Hr / Week Credit:01	**Examination Scheme** Internal Assessment: 60 Marks End Sem Exam: 40 Marks

Unit	Contents	Hrs.
1	Write a program to draw the per unit reactance diagram of a given power system.	**2**
2	Solution of building the Bus Admittance matrix for given power system network.	**2**
3	Solution of power flow problem of a given power system using Gauss-Siedel method.	**2**
4	Solution of power flow problem of a given power system using Newton Raphson Method.	**2**
5	Solution of power flow problem of a given power system using Fast Decoupled method.	**2**
6	Single Line to Ground Fault (L-G) analysis of a Three Phase Transmission Line at no load and light load conditions.	**2**
	Line to Line Fault (L-L) analysis of Three Phase Transmission Line at No load and Light load conditions.	**2**
7	Double Line to Ground Fault (LLG) analysis of Three Phase Transmission Line at No load and Light load conditions.	**2**
8	9. Symmetrical L-L-L Fault analysis of Three Phase Transmission Line at No load and Light load conditions.	**2**

Power Electronics Lab

Teaching Scheme	Examination Scheme
Practical: 02 Hr / Week Credit:01	Internal Assessment: 60 Marks End Sem Exam: 40 Marks

Unit	Contents	Hrs.
1	To study the static and dynamic characteristics of power semiconductor devices (SCR, MOSFET, IGBT, and TRIAC).	**2**
2	Experimental study of single-phase rectifiers: uncontrolled, half-controlled, and fully controlled converters.	**2**
3	Experimental analysis of single-phase inverters, including bridge inverter configurations.	**2**
4	Experimental study of DC-DC converters (Buck, Boost, and Buck-Boost converters).	**2**
5	To Study Class A, Class B, Class C, Class D and Class E Commutation.	
6	Simulation of Single phase Semi controlled converter	**2**
7	Simulation of Single phase Fully controlled converter	**2**
8	Simulation of Single-phase inverter	**2**
9	Simulation of BUCK /BOOST/BUCK -BOOST converter	**2**

Electrical Machine II Lab	
Teaching Scheme Practical: 02 Hr / Week Credit:01	**Examination Scheme** Internal Assessment: 60 Marks End Sem Exam: 40 Marks

Unit	Contents	Hrs.
1	To perform load and block rotor tests on a squirrel cage induction motor to determine its equivalent circuit parameters and performance characteristics.	**2**
2	To conduct a brake test on a slip ring induction motor to evaluate its torque, power output, and efficiency under loaded conditions.	**2**
3	To control the speed of a wound rotor induction motor by varying the rotor resistance and analyze the effect of rotor resistance on motor speed and torque.	**2**
4	To control the speed of an induction motor using the variable frequency (V/F) control method and study the relationship between voltage, frequency, and motor speed.	**2**
5	To control the speed of an induction motor using (i) star-delta starter and (ii) autotransformer starter, and analyze the starting current and torque characteristics	**2**
6	To conduct no load and blocked rotor test and to determine performance characteristics of three phase induction motor from circle diagram	**2**
7	To study the operation of a rotor resistance starter for a slip ring induction motor and analyze its effect on starting current and torque.	**2**
8	To study and compare the operation of different types of starters (e.g., DOL, star-delta, autotransformer) for a three-phase squirrel cage induction motor	**2**
9	To measure the armature and field resistance of a DC machine using appropriate methods and understand their significance in machine performance.	**2**
10	To determine the voltage regulation of an alternator under no-load and full-load conditions using the direct loading method.	**2**
11	To conduct a load test on an alternator to evaluate its voltage regulation, efficiency, and performance under varying load conditions.	**2**
9	To determine the positive, negative, and zero sequence impedances of a salient pole synchronous machine.	**2**
10	To determine the direct-axis (Xd) and quadrature-axis (Xq) reactances of a salient pole synchronous machine using the slip test method.	**2**
11	To plot the V and inverted V curves of a three-phase synchronous motor and analyze the effect of excitation on power factor and armature current.	**2**
12	To determine the voltage regulation of an alternator using the direct loading method with resistive (R), inductive (L), and capacitive (C) loads.	**2**
13	To determine the voltage regulation of an alternator using the synchronous impedance method and compare it with other methods.	**2**
14	To determine the voltage regulation of an alternator using the magnetomotive force (MMF) method and analyze its accuracy.	**2**
15	To study the parallel operation of synchronous generators and analyze the conditions for proper synchronization, load sharing, and stability.	**2**

Semester VI		
Switchgear and Protection		
Teaching Scheme Lectures Theory: 03Hr / Week Credit:03	**Examination Scheme** Internal Assessment: 20 Marks Mid-Sem Exam: 20 Marks End Sem Exam: 60 Marks	

Course Objectives:

1. To provide fundamental knowledge about the need for power system protection
2. To familiarize students with different types of relays, their operating principles, and application areas
3. To impart a detailed understanding of static and numerical relays, their algorithms, and their advanced applications
4. To introduce the concepts of **circuit breakers**, arc interruption techniques, fuse characteristics, and their application in power system safety.
5. To equip students with the knowledge of protection schemes for transmission Network, alternators, transformers, Rotating machine.

Course Outcome:

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

CO1. Understand the necessity of power system protection, analyze fault effects, and explain the philosophy of protection, zones of protection, and primary and backup protection schemes

CO2. Explain the operating principles and characteristics of different types of relays, including static, numerical, and microprocessor-based relays.

CO3. Demonstrate a comprehensive understanding of circuit breakers, their types, ratings, and performance during fault conditions, as well as the role of fuses in power systems

CO4. Analyze protection schemes for transmission lines, including overcurrent protection, distance relays, and carrier current protection.

CO5. Develop protection strategies for alternators and transformers, including differential protection, rotor and stator protection, and unbalanced loading protection.

Unit	Contents	Hrs.
1	**Introduction to Power System Protection:** Need for protective schemes, Nature and Cause of Faults, Types of Faults, Effects of Faults, Fault Statistics, Zones of Protection, Primary and Backup Protection, Essential Qualities of Protection, Performance of Protective Relaying, Classification of Protective Relays, Automatic Reclosing, Current Transformers for protection, Voltage Transformers for Protection. Relay Construction and Operating Principles: Introduction, Electromechanical Relays, Static Relays – Merits and Demerits of Static Relays, Numerical Relays, Comparison between Electromechanical Relays and Numerical Relays.	**7**
2	**Circuit Breakers:** Introduction, Fault Clearing Time of a Circuit Breaker, Arc Voltage, Arc Interruption, Restriking Voltage and Recovery Voltage, Current Chopping, Interruption of Capacitive Current, Classification of Circuit Breakers, Air – Break Circuit Breakers, Oil Circuit Breakers, Air – Blast Circuit Breakers, SF6 Circuit Breakers, Vacuum Circuit Breakers, High Voltage Direct Current Circuit Breakers, Rating of Circuit Breakers, Testing of Circuit Breakers.	**6**

3	**Overcurrent Protection Introduction** Time – current Characteristics, Current Setting, Time Setting. Overcurrent Protective Schemes, Reverse Power or Directional Relay, Protection of Parallel Feeders, Protection of Ring Mains, Earth Fault and Phase Fault Protection, Combined Earth Fault and Phase Fault Protective Scheme, Phase Fault Protective Scheme, Directional Earth Fault Relay, Static Overcurrent Relays, Numerical Overcurrent Relays. Microprocessor -based Protective Relays: Introduction, Overcurrent relays, Impedance relay. Directional Relay, Reactance Relay.	**7**
4	**Pilot Relaying Schemes:** Introduction, Wire Pilot Protection, Carrier Current Protection. Differential Protection: Introduction, Differential Relays, Simple Differential Protection, Percentage or Biased Differential Relay, Differential Protection of 3 Phase Circuits, Balanced (Opposed) Voltage Differential Protection. **Rotating Machines Protection**: Introduction, Protection of Generators. Transformers and Bus zone Protection: Introduction, Transformer Protection, Bus zone Protection, Frame Leakage Protection.	**6**
5	**Fuses:** Introductions, Definitions, Fuse Characteristics, Types of Fuses, Applications of HRC Fuses, Selection of Fuses, Discrimination. Protection against Over voltages: Causes of Over voltages, Lightning phenomena, Wave Shape of Voltage due to Lightning, Over Voltage due to Lightning, Protection of Transmission Lines against Direct Lightning Strokes, Protection of Stations and Sub – Stations from Direct Strokes, Protection against Travelling Waves, Insulation Coordination, Basic Impulse Insulation Level (BIL).	**6**
	Textbooks: 1. Power System Protection and Switchgear Badri Ram, D.N. Vishwakarma McGraw Hill 2nd Edition, 2011 2. Power System Protection and Switchgear Bhuvanesh Oza et al McGraw Hill 1st Edition, 2010 3. Power System Protection, Paul M. Anderson, Wiley-IEEE Press. 1999 ***Reference Books:*** 1. Power system protection and switchgear‖, Ravindranath and Chander, TMH, 2nd Edition, 2005 2. Fundamentals of power system protection‖, Paithankar and Bhide, PHI, 2010 3. J. L. Blackburn and T. J. Domin, Protective Relaying: Principles & Applications, CRC Press, 2006 4. Power System Protection: Fundamentals and Applications, C. Christopoulos, A. Wright, IET, 1999 5. Electrical Power Systems Quality, Roger C. Dugan, Mark F. McGranaghan, Surya Santoso, H. Wayne Beaty, McGraw-Hill Education. 2012 6. Electrical power system‖, Wadhwa, New Age. 2010 7. Protection and Switchgear Bhavesh et al Oxford 1st Edition, 2011 8. Fuses: Physics and Applications, Wright, A., Newbery, P.G., IET, 4th edition, 2004 9. Lightning Protection, Vernon Cooray, IET. 1st Edition, 2009 10. Power System Switchgear and Protection N. Veerappan S.R. Krishnamurthy S. Chand 1st Edition, 2009	

Electrical Machine Design

Teaching Scheme	Examination Scheme
Lectures Theory: 03 Hr / Week Credit:03	Internal Assessment: 20 Marks Mid-Sem Exam: 20 Marks End Sem Exam: 60 Marks

Course Objective:

1. To impart fundamental knowledge of electrical machine design principles.
2. To enable students to understand the design considerations and limitations involved in the design of various electrical machines.
3. To provide students with the ability to analyze and design key components of electrical machines.
4. To introduce students to the concepts of computer-aided design (CAD) in the context of electrical machines.
5. To develop practical skills in applying design principles to real-world electrical machine design problems.

Course Outcome:

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

CO1. Students will be able to explain the fundamental principles of electrical machine design, including design factors, limitations, and considerations.

CO2. Students will be able to design and analyze transformers, considering factors like core and winding design, losses, and cooling.

CO3. Students will be able to design simple electrical apparatus such as heating coils, starters, and chokes.

CO4. Students will be able to design stator and rotor components of three-phase induction motors, considering factors like specific loadings, slot numbers, and air gap length.

CO5. Students will be able to analyze the thermal behavior of electrical machines, including heat generation, dissipation, and cooling methods.

Unit	Contents	Hrs.
1	**Principles of Electrical Machine Design:** Principles of design, design factors, limitations, Ratings, Specifications, Standards, Performance and other criteria to be considered, Brief study of magnetic, electric, dielectric and other materials, Introduction and advantages of various approaches of Computer Aided Designing.	**6**
2.	**Design of Transformer:** Design of Transformer: Design of distribution and power transformers, Types, Classification and specifications, Design and main dimensions of core, yoke, winding, tank (with and without cooling tubes), Estimation of leakage reactance, resistance of winding, no load current, Losses, Mechanical force developed during short circuits, their estimation and measures to reduce them, Numerical examples	**6**

3	**Design of Simple Electrical Apparatus& AC and DC Windings:** Detailed design of heating coils, starters, chokes and lifting magnets, Numerical examples. **AC & DC Windings**: Constructional features, types of ac windings, Choice and design of simple/ duplex lap and wave winding, Concept of multiplex windings and reasons for choosing them, Single and double layer three phase AC winding (mush) with integral slots	**8**
4	**Design of Induction Motor** **(Stator):** Calculation of Ampere-Turns for flux distribution in rotating machines, Calculation of Ampere-Turns for flux distribution in rotating machines, output equation of three phase IM, specific electrical and magnetic loadings, ranges of specific loadings, turns per phase, number of stator slots, calculations for main dimensions, stator design parameters, Numerical examples. **(Rotor):** Selection of length of air gap, factors affecting length of air gap, design of rotor, Unbalanced magnetic pull and its estimation, harmonic field effect on the performance of3-phase induction motor, Design of squirrel cage and wound rotor	**6**
5	**Heating and Ventilation of Electrical Machines:** Study of different modes of heat generation, Temperature rise and heat dissipation, Heating and Cooling cycles, heating and cooling time constants, their estimation, dependence and applications, Methods of cooling / ventilation of electrical apparatus, Thermal resistance, radiated heat quantity of cooling medium (Coolant) Numerical examples.	**6**
	Textbooks: *1. Sawhaney. A. K– A Course in Electrical Machine Design (DhanpatRai),* ***Revised Edition, 2015*** ***Reference:*** 1. Deshpande. M. V- A Course in Electrical Machine Design (Prentice Hall Of India). 1st Edition 2015 2. Siskind – Electrical Machine Design (Mcgraw Hill), 1st Edition 2015 3. Design of Electrical Machines, V. N. Mittle, Arvind Mittle, McGraw-Hill Education, 1st Edition 2002 4. Principles of Electrical Machine Design, R. K. Agarwal, S. Chand Publishing. 1st Edition 2007 5. Design and Testing of Electrical Machines, M. V. Deshpande, PHI Learning. 2nd Edition, 2015	

Control System

Teaching Scheme	Examination Scheme
Lectures Theory: 03Hr / Week	Internal Assessment: 20 Marks
Credit:03	Mid-Sem Exam: 20 Marks
	End Sem Exam: 60 Marks

Course Objective:

1. The course Control Systems is the study of the analysis and regulation of the output behaviors of dynamical systems subject to input signals
2. This course focuses on the fundamental theories and design techniques for linear time-invariant systems feedback controllers.
3. The course provides techniques to present the physical systems into mathematical models and then analyze using time-domain & frequency domain
4. To introduce the state-space representation of control systems and provide students with the tools to analyze and design systems using state-space methods.
5. To familiarize students with the design and implementation of various controllers (P, I, D, PI, PID)

Course Outcome:

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

CO1. To know different basic concepts and components of a control system

CO2. To derive transfer functions of basic control system components.

CO3. To perform stability analysis using time domain and frequency domain response on a given system

CO4. To design and analyze PID controller.

CO5. To understand and analyze state variable technique.

Unit	Contents	Hrs.
1	**Introduction to control system** Concept of open & closed loop control system, Transfer Function: Concept of system: Physical system, Physical model, Equations of physical systems (Mechanical, Rotational and Electrical) Transfer Function, Block diagrams and Signal flow graphs: a) Block diagram, Block Diagram reduction, and Numerical examples. b) Signal flow graph; Masons gain formula for deriving overall transfer function of systems. Concept of Negative and Positive feedback, Sensitivity of the system to parameter variation and with negative and positive feedback.	**7**
2	**Time Domain Analysis** Typical test signals, Time domain specifications, Steady state response, Types of system, Steady State Error constants and Steady State Error, Transient Response, Concept of stability, Determination of stability by Routh array criterion.	**7**
3	**Stability and Frequency Response Analysis** **Root Locus concept** - Construction, and Stability from Root Locus plots, Effect of addition of poles & zeros on Root Locus plots. **Introduction to Frequency Domain Analysis** – stability analysis from Bode plots, Polar plots Nyquist criterion.	**7**

4	**Compensation Technique and Controllers** **Compensation network:** Lag, Lead & Lag – Lead compensation. **Controllers**: Introduction to Proportional (P), Integral (I) & Derivative (D) controller, individual effect on overall system performance, P-PI & PID control and effect on overall system performance.	**6**
5	**State Space Analysis** Concept of State, State Variable & State Vector, State Variable Analysis: Different forms of state variable representations, Concept of Diagonalization, Obtaining State Equations from Transfer Function representation and vice versa, Solution of State Equations, State Transition Matrix (STM), Methods of finding STM, Calay Hamilton Method, Controllability & Observability of linear system, Kalman's test.	**6**
	Reference Books: 1. M. Gopal, *Control Systems: Principles and Design*, McGraw Hill Education, 4th Edition, 2012. 2. Benjamin C. Kuo, *Automatic Control Systems*, Prentice Hall of India, 8th Edition, 2003. 3. I.J. Nagrath, M. Gopal, *Control Systems Engineering*, New Age International, 6th Edition, 2017. 4. Richard C. Dorf, Robert H. Bishop, *Modern Control Systems*, Pearson, 13th Edition, 2016. 5. Norman S. Nise, *Control Systems Engineering*, Wiley, 7th Edition, 2015. *6.* Benjamin C. Kuo, Farid Golnaraghi, *Automatic Control Systems*, Wiley, 9th Edition, 2014. *7.* Gene F. Franklin, J. David Powell, Abbas Emami-Naeini, *Feedback Control of Dynamic Systems*, Pearson, 8th Edition, 2019. ***Text Books:*** 1. Katsuhiko Ogata, *Modern Control Engineering*, Prentice Hall, 5th Edition, 2010. 2. Norman S. Nise, *Control Systems Engineering*, Wiley India, 7th Edition, 2015. 3. Smarajit Ghosh, *Control Systems: Theory and Applications*, Pearson Education, 1st Edition, 2007.	

Program Elective-II	
(A) Electrical Utilization	
Teaching Scheme Lectures Theory: 03Hr / Week Credit:03	**Examination Scheme** Internal Assessment: 20 Marks Mid-Sem Exam: 20 Marks End Sem Exam: 60 Marks

Course Objective:

1. To understand the principles, advantages, and applications of electrical heating methods, including resistance heating, arc furnaces
2. To study various electric welding techniques, including arc welding, resistance welding, and modern methods.
3. To explore Faraday's laws of electrolysis and their applications in electroplating, anodizing, electrical polishing, and electroextraction.
4. To learn the principles of good lighting, classify light fittings and luminaries, and design indoor and outdoor lighting schemes for factories, floodlights, and streetlights.
5. To understand the working of electric traction systems, including DC and AC transmission systems.

Course Outcome:

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

CO1. Explain the advantages of electrical heating and design heating elements for resistance ovens, while controlling temperature effectively.

CO2. Compare and contrast different electric welding methods, including arc welding, resistance welding, ultrasonic welding, and laser welding

CO3. Apply Faraday's laws of electrolysis to processes like electroplating, anodizing, and electro extraction.

CO4. Analyze different electric traction systems, including DC and AC transmission systems, and evaluate the suitability of battery drives, hybrid drives, and flywheel.

CO5. explain the characteristics and constructional details of DC series motors and their suitability for traction duties.

Unit	Contents	Hrs.
1	**Industrial Utilization of Electric Motors:** Review of nature of mechanical load, Matching of speed torque characteristics of load & motor, Starting condition of the load & calculation of starting time for motors, Standard loading at motors load equalization, Control devices, Pilot devices via push buttons, Limit switches, Float switches, Pressure switches, Thermostats, Plugging switches, Contactor relays & solenoid values, Simple line diagrams using above devices, Applications of electrical motors in textiles mills, Mines cranes, Lifts, Excavators, Marine drives pumps, Refrigerators & air conditioning.	**7**
2	**Electrolytic Processes:** Faradays laws of electrolysis, Application of electrolysis, Like Electroplating, anodizing electrical polishing & electroextraction, Accumulators & cell, Types & construction, Charging & discharging, recent trends in manufacturing of batteries.	**6**

3	**Illumination:** Requirement of good lighting, Classification of light fitting & luminaries, Factor to be considered for design of indoor & outdoor lighting scheme, Design procedure for factory lighting, flood lighting & street lighting.	**6**
4	**Electrical Heating:** Advantages of electrical heating, Resistance heating, Design of heating element in resistance oven, Control of temperature in resistance oven, Electric arc furnaces, Induction furnaces, Dielectric heating. Electric Welding: Electric arc welding & Resistance welding, Modern welding techniques like Ultrasonic & Laser welding	**6**
5	**Electrical Traction:** Features of an Ideal Traction System, Systems of Electrical Traction, Mechanism of Train Movement, Speed- Time Curve, Traction Supply System, Transmission Line to Substation, Feeding and Distribution System on an AC Traction, System of Current Collection, Traction Motors, Tractive Effort and Horsepower, Speed Control Schemes, Electric Braking	**6**
	Text Books 1. E. Openshaw Taylor, Utilization of Electrical Energy, Orient Longman, 1st Edition, 1968. 2. J.B. Gupta, Utilization of Electric Power and Electric Traction, S.K. Kataria & Sons, 10th Edition, 2002. ***Reference Books*** 1. J.B. Gupta, S. Garg, R. Girdhar, Utilisation of Electric Energy and Electric Traction, Khanna Publishers, Revised Edition, 1982. 2. S.C. Tripathy, Electric Energy Utilization and Conservation, Tata McGraw-Hill, 1st Edition, 1993. 3. C.L. Wadhwa, Generation, Distribution and Utilization of Electrical Energy, New Age International, 3rd Edition, 2010. 4. H. Partab, Art and Science of Utilization of Electrical Energy, Dhanpat Rai & Sons, 2nd Edition, 2004. 5. IEEE Industry Applications Society, IEEE Recommended Practice for Electric Power Distribution for Industrial Plants (Bronze Book), IEEE Press, Latest Edition.	

Program Elective-II	
(B)Transients in Electrical Power System	
Teaching Scheme Lectures Theory: 03Hr / Week Credit:03	**Examination Scheme** Internal Assessment: 20 Marks Mid-Sem Exam: 20 Marks End Sem Exam: 60 Marks

Course Objective:

1. To provide a comprehensive understanding of the nature, causes, and effects of transients in electrical power systems.
2. To equip students with the knowledge to analyze transient phenomena in RL, RC, and RLC circuits, as well as in power systems.
3. To study the overvoltage's caused by switching operations, including resistance switching, load switching, and capacitance switching.
4. To explore the mechanisms of lightning formation, its interaction with power systems.
5. To examine transient phenomena in integrated power systems, including line dropping, load rejection, and fault-induced overvoltage's.

Course Outcome:

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

CO1. Describe the causes and effects of transients in power systems, including switching and lightning-induced transients, and their impact on system performance.

CO2. Analyze transient behavior in RL, RC, and RLC circuits, including double-frequency transients and the effects of sinusoidal excitation.

CO3. Evaluate overvoltage's caused by switching operations, such as resistance switching, load switching, and capacitance switching.

CO4. Apply the concept of traveling waves to analyze transient phenomena on transmission lines, including reflection, refraction, and the use of Bewley's lattice diagram.

CO5. Gain familiarity with computational tools like EMTP for qualitative analysis of transients in integrated power systems.

Unit	Contents	Hrs.
1	**INTRODUCTION AND SURVEY:** Review and importance of the study of transients - causes for transients. RL circuit transient with sine wave excitation - double frequency transients - basic transforms of the RLC circuit transients. Different types of power system transients - effect of transients on power systems – role of the study of transients in system planning.	7
2	**SWITCHING TRANSIENTS** Over voltages due to switching transients - resistance switching and the equivalent circuit for interrupting the resistor current - load switching and equivalent circuit - waveforms for transient voltage across the load and the switch - normal and abnormal switching transients. Current suppression - current chopping - effective equivalent circuit. Capacitance switching -effect of source regulation - capacitance switching with a restrike" with multiple restrikes. illustration for multiple restriking transients - ferro resonance.	7

3	**LIGHTNING TRANSIENTS** Review of the theories in the formation of clouds and charge formation - rate of charging of thunder clouds – mechanism of lightning discharges and characteristics of lightning strokes – model for lightning stroke - factors contributing to good line design - protection using ground wires – tower footing resistance - #nteraction between lightning and power system.	**7**
4	**TRAVELING WAVES ON TRANSMISSION LINE COMPUTATION OFTRANSIENTS** Computation of transients - transient response of systems with series and shunt lumped parameters and distributed lines. Traveling wave concept - step response Bewely's lattice diagram – standing waves and natural frequencies - reflection and refraction of travelling waves.	**7**
5	**TRANSIENTS IN INTEGRATED POWER SYSTEM** The short line and Kilometric fault - distribution of voltages in a power system – Line dropping and load rejection - voltage transients on closing and reclosing lines - over voltage induced by faults –switching surges on integrated system qualitative application of EMTP for transient computation.	**7**
	Textbooks: 1. Allan Greenwood, 'Electrical Transients in Power Systems', Wiley Inter Science, New York, 2nd Edition, 1991. 2. Pritindra Chowdhari, "Electromagnetic transients in Power System", John Wiley and Sons Inc., Second Edition, 2009. 3. C.S. Indulkar, D.P.Kothari, K. Ramalingam, 'Power System Transients A statistical approach', PHI Learning Private Limited, Second Edition, 2010. ***References***: 1. M.S.Naidu and V.Kamaraju, 'High Voltage Engineering', Tata McGraw Hill, Fifth Edition, 2013. 2. R.D. BegamAFre, 'Extra High Voltage AC Transmission Engineering', Wiley Eastern Limited, 1986. 3. Y.Hase, Handbook of Power System Engineering," Wiley India, 2012. 4. J.L.Kirtley, "Electric Power Principles, Sources, Conversion, Distribution and use," Wiley, 2012.	

Program Elective-II	
(C) Electrical Vehicle	
Teaching Scheme Lectures Theory: 03Hr / Week Credit:03	**Examination Scheme** Internal Assessment: 20 Marks Mid-Sem Exam: 20 Marks End Sem Exam: 60 Marks

Course Objective:

4. To provide students with a foundational understanding of the history, social and environmental importance of electric vehicles, and the impact of modern drive-trains on energy supplies.
5. To introduce students to various electric drive-train topologies, their operation, and power flow control strategies.
6. To familiarize students with the electric components used in electric vehicles and the control techniques for different types of electric motors
7. To equip students with knowledge of energy storage requirements, battery modeling, different battery types, supercapacitors, and hybridization of energy storage devices.
8. To enable students to understand energy management strategies in electric vehicles, charging infrastructure, and communication protocols.

Course Outcome:

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

CO1: Illustrate electric vehicles. (L2)

CO2: Understand drive-train topologies. (L2)

CO3: Classify various electrical drives (L2)

CO4: Classify energy storage technologies. (L2)

CO5: Classify different energy management strategies. (L2)

Unit	Contents	Hrs.
1	**INTRODUCTION TO ELECTRIC VEHICLES**: History of electric vehicles, social and environmental importance of electric vehicles, impact of modern drive-trains on energy supplies. **CASE STUDY** Comparison by efficiency of Conventional, Hybrid, Electric and Fuel cell Vehicles.	**7**
2	**ELECTRIC DRIVE-TRAINS** Basic concept of electric traction, Introduction to various electric drive-train topologies, Power flow control in electric drive-train topologies.	**6**
3	**ELECTRIC DRIVES & CONTROL** Introduction to electric components used in electric vehicles, Control of Induction Motor Drive, Permanent Magnet (PM) motor Drive & Switched Reluctance Motor (SRM) Drive.	**6**
4	**ENERGY STORAGE** Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its modeling, SOC, Different Types of Batteries, Super Capacitor based energy storage and its analysis, Hybridization of different energy storage devices.	**7**

5	**ENERGY MANAGEMENT STRATEGIES & CHARGING INFRASTRUCTURE** Introduction to energy management strategies used in electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies, Types of EV charging Infrastructure & Standardized Communication protocols for EV charging. **CASE STUDIES** Current issues in electric Vehicles, Thermal Protection of Battery.	**7**
	Textbooks 1. James Larminie, John Lowry, *Electric Vehicle Technology Explained*, Wiley, 2nd Edition, 2012. 2. James Larminie, John Lowry, *Electric Vehicle Technology Explained*, Wiley, 1st Edition, 2003. ***Reference Books*** 3. International Energy Agency (IEA), *Electric Vehicle Charging Infrastructure: Guidelines for Countries and Cities*, IEA Publications, 1st Edition, 2022. 4. Enrico Levi, Emilio Levi, *Electric Vehicle Engineering: Performance and Design*, Springer, 1st Edition, 2019. 5. James Larminie, *Electric Vehicle Technology: A Guide for Understanding the Basics of Electric Vehicles*, Wiley, 2012. 6. David Beeton, Gereon Meyer, *Electric Vehicle Business Models: Global Perspectives*, Springer, 1st Edition, 2014. 7. Gianfranco Pistoia (Editor), *Electric Vehicle Battery Technologies*, Elsevier, 1st Edition, 2014. 8. Kevin A. Wilson, *Electric Vehicles: The Future Is Now!*, Motorbooks, 1st Edition, 2019.	

Program Elective-II

(D) Embedded Systems

Teaching Scheme	Examination Scheme
Lectures Theory: 03 Hr / Week	Internal Assessment: 20 Marks
Credit:03	Mid-Sem Exam: 20 Marks
	End Sem Exam: 60 Marks

Course Objective:

1. To provide students with a fundamental understanding of computer architecture, binary number systems, and their relevance to embedded systems.
2. To introduce students to the core concepts of embedded systems, their characteristics, and classifications.
3. To familiarize students with the essential hardware components of embedded systems, including microcontrollers, memory, and low-power design considerations.
4. To equip students with the knowledge of interfacing sensors, ADCs, and actuators, which are crucial for interacting with the real world.
5. To expose students to diverse examples of embedded systems in various application domains, showcasing their practical relevance.

Course Outcome:

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

CO1. learn about the general principles of computer architecture

CO2. learn about the working of a simple embedded system and embedded system applications

CO3. learn the hardware aspects of embedded systems

CO4. understand the sensors, ADCs and actuators used in embedded systems

CO5. understand the real-world examples of embedded systems

Unit	Contents	Hrs.
1	**Basics of computer architecture and the binary number system** Basics of computer architecture, computer languages, RISC and CISC architectures, number systems, number format conversions, computer arithmetic, units of memory capacity.	6
2	**Introduction to embedded systems** Application domain of embedded systems, desirable features and general characteristics of embedded systems, model of an embedded system, microprocessor Vs microcontroller, example of a simple embedded system, figure of merit for an embedded system, classification of MCUs: 4/8/16/32 bits, history of embedded systems, current trends.	6
3	**Embedded systems-The hardware point of view** Microcontroller unit (MCU), a popular 8-bit MCU, memory for embedded systems, low power design, pull up and pull-down resistors.	6
4	**Sensors, ADCs and Actuators** Sensors: Temperature Sensor, Light Sensor, Proximity/range Sensor; Analog to digital converters: ADC Interfacing; Actuators Displays, Motors, Opto couplers/Opto isolators, relays.	6
5	**Examples of embedded systems** Mobile phone, automotive electronics, radio frequency identification (RFID), wireless sensor Networks (WISENET), robotics, biomedical applications, brain machine interface.	6

	Textbooks 1. K.V. Shibu, *Introduction to Embedded Systems*, Tata McGraw-Hill, 1st Edition, 2009. 2. B. Kanta Rao, *Embedded Systems*, PHI Learning, 1st Edition, 2009. 3. Frank Vahid, Tony Givargis, *Embedded System Design: A Unified Hardware/Software Introduction*, John Wiley & Sons, 2nd Edition, 2006. ***Reference Books*** 1. William Stallings, *Computer Organization and Architecture: Designing for Performance*, Pearson, 11th Edition, 2018. 2. John L. Hennessy, David A. Patterson, *Computer Architecture: A Quantitative Approach*, Morgan Kaufmann, 6th Edition, 2017. 3. Sarah Harris, David Harris, *Digital Design and Computer Architecture*, Morgan Kaufmann, 2nd Edition, 2012. 4. James K. Peckol, *Embedded Systems: A Contemporary Design Tool*, Wiley, 2nd Edition, 2019. 5. Raj Kamal, *Embedded Systems: Architecture, Programming and Design*, McGraw-Hill Education, 3rd Edition, 2017.	

Program Elective-III		
(A) Flexible AC Transmission System		
Teaching Scheme Lectures Theory: 03 Hr / Week Credit:03		**Examination Scheme** Internal Assessment: 20 Marks Mid-Sem Exam: 20 Marks End Sem Exam: 60 Marks
Course Objective: 6. Understand the concepts of Flexible Power Transmission 7. Understand Ideal shunt and practical shunt compensation using Thyristors (TCR) and Bridge Converters (STATCOM) 8. Understand the concepts of ideal series, practical series using Thyristors (TCSC) and Converters (SSSC) 9. Understand the concepts of Transient Stability Enhancement and Power Oscillation Damping using shunt and series compensation		
Course Outcome: **After completion of this course, students will be able to:** CO1 Classify the FACTS devices into Thyristor based and Converter based. CO2 Insight into the Transient Stability Enhancement, Power Oscillation Damping, Transient Stability Margin. CO3 Understanding the voltage and the current waveforms with respect to thyristors and the converters for both shunt and series compensation. CO4 Understanding the dynamics of stability of voltage regulation using SVC and STATCOM with the variation of line reactance. CO5 Conceptual understanding of independently controlling the active and the reactive power through circular control regions.		
Unit	**Contents**	**Hrs.**
1	**Transmission Interconnection** Flow of power in the AC system, factors affecting loading capability, power flow and dynamic stability consideration of a Transmission interconnection, Description and application of HVDC transmission, DC System components and their functions, Converter configuration, Principles of DC Link control and Converter control characteristics, Firing angle, Current and extinction angle control, DC link power control	**6**
2	**Introduction to FACTS** Benefits of FACTS, Basic Realities & Roles, Types of FACTS Controller, Principles of Series and Shunt Compensation. Introduction to Voltage source and Current source converter. Shunt compensation (SVC): Objectives of shunt compensation, Midpoint voltage regulation for long transmission line, voltage instability prevention, improvement of transient stability	**6**
3	**Reactive power control and VAR sources** Reactive power control and VAR sources Methods of controllable VAR generation, Description of Static VAR Compensators (SVC), Variable impedance type VAR generators. Thyristor controlled reactor (TCR), Thyristor Switched Capacitor (TSC), TSC-TCR, Fixed capacitor TCR (FCTCR). Shunt compensation	**6**

4	**Variable impedance type series compensator** Thyristor Switches Series Capacitor (TSSC), Thyristor Controlled Series Compensators (TCSC). Switching Converter type Series Compensator. Introduction to interline power flow controller, Special purpose FACTS controllers, Thyristor controlled voltage limiter and voltage regulator, Thyristor controlled braking resistor and current limiter	**6**
5	**STATCOM** Switching type VAR generator, Static Synchronous Compensator (STATCOM), Basic operating principle, Configuration. Basic control approach, Comparison between SVC and STATCOM. Series Compensator: Objectives of series compensation, improvement of transient stability Synchronous Series Compensator: (SSSC) and Controller for SSSC, Basic configuration and working of Unified Power Flow Controller (UPFC). Unified Power Flow Controller, Circuit Arrangement, Basic Principle of P and Q Control, independent real and reactive power flow control, Applications GCSC, TSSC, TCSC & SSSC	**6**
	Text Books 1. Xiao-Ping Zhang, Christian Rehtanz, Bikash Pal, *Flexible AC Transmission Systems: Modelling and Control*, Springer, 1st Edition, 2006. 2. Enrique Acha, Claudio R. Fuerte-Esquivel, Hugo Ambriz-Pérez, César Angeles-Camacho, *FACTS Modelling and Simulation in Power Networks*, Wiley India, Indian Edition, 2012. 3. R. Mohan Mathur, Rajiv K. Verma, *Thyristor-Based FACTS Controllers for Electrical Transmission Systems*, IEEE Press/Wiley India, 1st Edition, 2002. **Reference Books** 1. N.G. Hingorani, L. Gyugyi, *Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems*, IEEE Press, 1st Edition, 1999. 2. Y.H. Song, A.T. Johns, *Flexible AC Transmission Systems (FACTS)*, IET, 1st Edition, 1999. 3. K.R. Padiyar, *FACTS Controllers in Power Transmission and Distribution*, New Age International Publishers, 1st Edition, 2007. 4. T.J.E. Miller, *Reactive Power Control in Electric Systems*, John Wiley & Sons, 1st Edition, 1982.	

Program Elective-III	
(B) Power Quality Issue	
Teaching Scheme Lectures Theory: 03Hr / Week Credit:03	**Examination Scheme** Internal Assessment: 20 Marks Mid-Sem Exam: 20 Marks End Sem Exam: 60 Marks

Course Objective:

1. Understand power quality issues and their impact.
2. Learn sources and mitigation techniques for various PQ problems.
3. Analyze harmonics, their sources, and effects on power systems.
4. Understand voltage regulation principles and methods.
5. Learn power quality monitoring techniques and data analysis.

Course Outcome:

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

CO1 Identify and classify different power quality disturbances.
CO2 Evaluate the impact of PQ problems on equipment and systems.
CO3 Design and implement solutions to mitigate PQ issues.
CO4 Analyze harmonic distortion and its impact on power system performance.
CO5 Interpret power quality data and generate reports for system improvement.

Unit	Contents	Hrs.
1	**Introduction:** **General Terms:** General Classes of Power Quality Problems, Transients, Long Duration Voltage Variations, Short-Duration Voltage Variations, Voltage Imbalance, Waveform Distortion, Voltage Fluctuations, Power Frequency Variations, ***Voltage Sags & Interruptions***: Sources of Sags and Interruptions, Estimating Voltage Sag Performance, Fundamental Principles of Protection, Solutions at the End-User Level, Evaluating the Economics of Different Ride-Through Alternatives, Motor Starting Sags, Utility System Fault-Clearing Issues.	**6**
2	***Transient Over Voltages***: Sources of Transient Over Voltages, Principle of Over Voltage Protection, Devices for Over Voltage Protection, Utility Capacitor-Switching Transients, Utility System Lightning Protection, Managing Ferro-resonance, Switching Transient Problems with Loads, Computer Tools for Transient Analysis.	**6**
3	***Fundamentals of Harmonics***: Harmonic Distortion, Voltage Versus Current Distortion, Harmonics Versus Transients, Power System Quantities under Non-sinusoidal Conditions, Harmonic Indices, Harmonic Sources from Commercial Loads, Locating Harmonic Sources, System Response Characteristics, Effects of Harmonic Distortion, Inter-harmonics.	**6**
4	***Long Duration Voltage Variations***: Principles of Regulating the Voltage, Devices for Voltage Regulation, Utility Voltage Regulator Application, Capacitors for Voltage Regulation, End-User Capacitor Application, Regulating Utility Voltage with Distributed resources, Flicker.	**6**

5	***Power Quality Monitoring***: Monitoring Considerations, Historical Perspective of Power Quality Measuring Instruments, Power Quality Measurement Equipment's, Assessment of Power Quality Measurement Data, Application of Intelligent Systems, Power Quality Monitoring Standards.	**6**
	Text / Reference Books 1. Surajit Chattopadhyay, Madhuchhanda Mitra, Samarjit Sengupta, *Electric Power Quality*, Springer, 1st Edition, 2011. 2. G.T. Heydt, *Electric Power Quality*, Stars in a Circle Publications, 2nd Edition, 1994. 3. Roger C. Dugan, Mark F. McGranaghan, Surya Santoso, H. Wayne Beaty, *Electrical Power Systems Quality*, McGraw-Hill Education, 3rd Edition, 2012. 4. J. Arrillaga, N.R. Watson, *Power System Harmonics*, Wiley, 2nd Edition, 2003. 5. J. Arrillaga, N.R. Watson, S. Chen, *Power Quality Following Deregulation*, Wiley, 1st Edition, 2000. 6. Math H.J. Bollen, *Understanding Power Quality Problems: Voltage Sags and Interruptions*, IEEE Press/Wiley, 1st Edition, 2000. 7. Francisco C. De La Rosa, *Harmonics and Power Systems*, CRC Press, 1st Edition, 2006. 8. Juan A. Martinez-Velasco (Editor), *Transient Analysis of Power Systems: Solution Techniques, Tools and Applications*, IET, 1st Edition, 2010.	

Program Elective-III	
(C) Industrial Automation & Control	
Teaching Scheme Lectures Theory: 03Hr / Week Credit:03	**Examination Scheme** Internal Assessment: 20 Marks Mid-Sem Exam: 20 Marks End Sem Exam: 60 Marks

Course Objective:

1. To introduce the concept of automation in manufacturing and process industries, including its principles, strategies, and basic elements.
2. To familiarize students with the advanced functions and levels of automation
3. To provide an overview of material handling systems, including the design and types of equipment, conveyor systems, automated guided vehicle systems.
4. To understand the architecture, programming languages, and instruction sets of PLCs, and to design alarm and interlock systems, network PLCs.
5. To explore the levels of process safety automation using PLCs, the integration of process safety PLCs with DCS.

Course Outcome:

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

CO1. Describe the principles, strategies, and basic elements of automation in manufacturing and process industries.

CO2. Analyze automated flow lines, transfer mechanisms, and the impact of storage buffers on production efficiency.

CO3. Explain the architecture and functioning of DDC, DCS, and SCADA systems.

CO4. Develop programs for PLCs using basic instruction sets, design alarm and interlock systems, and network PLCs for industrial applications.

CO5. Evaluate the effectiveness of automation solutions in improving productivity, safety, and efficiency in industrial settings.

Unit	Contents	Hrs.
1	**Automation in Manufacturing Industries- Introduction:** Introduction- Automation in production system, Principles and strategies of automation, Basic elements of an automated system, Advanced automation functions, Levels of automations, Automated flow lines and transfer mechanisms, Analysis of transfer lines without storage, Automated flow lines with storage buffers.	**6**
2	**Automation in Manufacturing Industries- Material handling and identification technologies**: Material handling and identification technologies -Overview of material handling systems, Types of material handling equipment, Design of the system, Conveyor system, Automated guided vehicle system, Automated storage systems, Interfacing handling and storage with manufacturing, Overview of Automatic Identification Methods.	**6**
3	**Automation in Process Industries- Introduction to computer based industrial automation:** Introduction to computer based industrial automation- Direct Digital Control	**6**

	(DDC), Distributed Control System (DCS) and supervisory control and data acquisition (SCADA) based architectures. SCADA for process industries includes understanding of RTUs, Pumping stations, Evacuation processes, Mass Flow Meters and other flow meters, Leak-flow studies of pipelines, Transport Automation.	
4	**Automation in Process Industries- Programmable Logic Controller (PLC):** Programmable Logic Controller (PLC)- Block diagram of PLC, Programming languages of PLC, Basic instruction sets, Design of alarm and interlocks, Networking of PLC, Overview of safety of PLC with case studies. Process Safety Automation: Levels of process safety through use of PLCs, Integrating Process safety PLC and DCS, Application of international standards in process safety control.	**6**
5	**Automation in Process Industries- Distributed Control System:** Distributed Control System- Local Control Unit (LCU) architecture, LCU Process Interfacing Issues, Block diagram and Overview of different LCU security design approaches, Networking of DCS. Introduction to communication protocols- Profibus, Field bus, HART protocols. Data gathering, Data analytics, Real-time analysis of data stream from DCS, Historian build, Integration of business inputs with process data, Leveraging RTU (as different from PLCs and DCS).	**6**
	Textbooks Mikell P. Groover, Automation, Production Systems, and Computer-Integrated Manufacturing, Pearson Education, 3rd Edition, 2008. 1. John W. Webb, Ronald A. Reis, Programmable Logic Controllers: Principles and Applications, Prentice Hall, 5th Edition, 2003. 2. Krishna Kant, Computer-Based Industrial Control, PHI Learning, 2nd Edition, 2011. 3. Frank D. Petruzella, Programmable Logic Controllers, McGraw-Hill Education, 5th Edition, 2016. ***Reference Books*** 1. Curtis D. Johnson, Process Control Instrumentation Technology, Pearson Education, 8th Edition, 2013. 2. M.P. Lukas, Distributed Control Systems: Their Evaluation and Design, Van Nostrand Reinhold Company, 1st Edition, 1986. 3. N. Viswanadham, Y. Narahari, Performance Modeling of Automated Manufacturing Systems, PHI Learning, 1st Edition, 1992.	

Program Elective-III	
(D) Robotics and Automation Engineering	
Teaching Scheme Lectures Theory: 03Hr / Week Credit:03	**Examination Scheme** Internal Assessment: 20 Marks Mid-Sem Exam: 20 Marks End Sem Exam: 60 Marks

Course Objective:

1. To provide a comprehensive understanding of robot anatomy, coordinate systems, and classification of robotic systems
2. To impart skills in deriving kinematic and dynamic models of robot manipulators using DH parameters and Lagrangian formulations
3. To study the selection and interfacing of various sensors
4. To apply classical and modern control theories for position, velocity, and trajectory tracking in robots
5. To develop proficiency in programming Programmable Logic Controllers (PLCs) and designing automated sequences

Course Outcome:

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

CO1. Perform forward and inverse kinematic analysis for various manipulator configurations

CO2. Design and simulate feedback control systems for robotic stability and accuracy.

CO3. Program PLCs using Ladder Logic or Functional Block Diagrams to solve discrete manufacturing problems

CO4. Select and integrate appropriate sensors for environmental perception and navigation.

CO5. Propose cost-effective and sustainable automation solutions for real-world industrial tasks

Unit	Contents	Hrs.
1	**Introduction to Robotics:** History and Evolution of Robots; Robot Anatomy: Links, Joints, and Degrees of Freedom (DOF). Classification of Robots (Cartesian, Cylindrical, Spherical, SCARA, Articulated). Robot End-Effectors: Grippers and Tools. Work Envelope and Precision: Resolution, Accuracy, and Repeatability.	6
2	**Robot Kinematics and Dynamics:** Coordinate Transformations: Rotation matrices, Homogeneous coordinates. **Kinematics:** Denavit-Hartenberg (D-H) representation; Forward and Inverse Kinematics of 2R/3R manipulators. Jacobian Matrix: Singularities and Statics. **Dynamics:** Euler-Lagrange and Newton-Euler formulations for simple robotic arms.	6
3	**Sensors and Actuators:**	6

	Actuators: DC Servo Motors, Stepper Motors, BLDC Motors; Hydraulic and Pneumatic systems for robotics. **Sensors:** Interoceptive (Encoders, Resolvers, Tachometers) and Exteroceptive (Proximity, Ultrasonic, Force/Torque sensors). Introduction to Machine Vision: Image processing basics, object recognition, and localization.	
4	. **Robot Control and Motion Planning:** Joint Space vs. Task Space Control. Trajectory Planning: Cubic and Quintic Polynomials; LSPB (Linear Segment with Parabolic Blends). Feedback Control: P, PI, and PID control for robot joints Introduction to Obstacle Avoidance and Path Planning algorithms.	**6**
5	**Industrial Automation and PLCs:** Architecture of Industrial Automation: Sensors, Actuators, and Controllers. **PLC Fundamentals:** Internal architecture, I/O modules, and Scan cycle. **Programming:** Ladder Logic, Instruction List, and Function Block Programming. Applications: Case studies in Material Handling, Automated Assembly, and SCADA integration.	**6**
	Textbooks 1. John J. Craig, Introduction to Robotics: Mechanics and Control, Pearson, 4th Edition, 2017. 2. Mikell P. Groover, Mitchell Weiss, Roger N. Nagel, Nicholas G. Odrey, Industrial Robotics: Technology, Programming, and Applications, McGraw-Hill, 1st Edition, 1986. 3. S.K. Saha, Introduction to Robotics, Tata McGraw-Hill Education, 2nd Edition, 2014. ***Reference Books*** 1. Mark W. Spong, Seth Hutchinson, M. Vidyasagar, Robot Modeling and Control, Wiley, 1st Edition, 2005. 2. Frank D. Petruzella, Programmable Logic Controllers, McGraw-Hill Education, 5th Edition, 2016. 3. W. Bolton, Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, Pearson, 6th Edition, 2015. 4. Bruno Siciliano, Oussama Khatib (Editors), Springer Handbook of Robotics, Springer, 2nd Edition, 2016.	

Electrical Maintenance and Commissioning of Electrical Equipment

Teaching Scheme	**Examination Scheme**
Practical: 02Hr / Week Credit:02	Internal Assessment: 20 Marks Mid-Sem Exam: 20 Marks End Sem Exam: 60 Marks

Course Objective:

1. To introduce students to the importance of maintenance and various maintenance strategies, including breakdown, planned, and condition-based maintenance.
2. To provide students with knowledge of planned and preventive maintenance procedures for transformers, induction motors, and alternators.
3. To familiarize students with the concept of condition monitoring and its importance in assessing the health of electrical equipment.
4. To introduce students to advanced tools and techniques used in condition monitoring, such as dissolved gas analysis and industrial sonography.
5. To equip students with the knowledge and skills to perform various tests on electrical equipment, diagnose faults, and implement appropriate remedies.

Course Outcome:

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

CO1. select and justify the most appropriate maintenance strategy for a given electrical system or component.
CO2. develop planned and preventive maintenance schedules for transformers, induction motors, and alternators.
CO3. apply condition monitoring techniques to assess health and identify potential failures in electrical equipment.
CO4. perform and interpret various tests on electrical equipment, diagnose faults, and recommend appropriate corrective actions.
CO5. explain the principles and applications of specialized testing methods

Unit	Contents	Hrs.
1	**Maintenance and Condition Monitoring**: Importance and necessity of maintenance, different maintenance strategies like Breakdown maintenance, planned maintenance and condition-based maintenance. Planned and preventive maintenance of transformers, induction motor and alternators. Insulation stressing factors, insulation deterioration, polarization index, dielectric absorption ratio. Concept of condition monitoring of electrical equipment's. Advanced tools and techniques of condition monitoring (Only theory)	7
2	**Condition Monitoring of Transformers**: Testing and condition monitoring of oil as per the IS/IEC standards. Filtration/reconditioning of insulating oil. Failure modes of transformer. Condition monitoring of transformer bushings, On load tap changer, dissolved gas analysis, degree of polymerization. IS/Specifications for testing transformer bushing and oil.	7
3	**Condition Monitoring of Induction Motors:** Parameters of induction motors, Induction motor fault diagnostic methods, the induction motor fault monitoring method and Remedies	7

4	**Testing of Electrical Equipment's:** Testing of Power cables – Causes of cable failure, fault location methods and Remedial actions, Testing of Transformer - Type tests, Routine tests and Special tests. Various abnormal conditions, trouble shooting, faults, causes and remedies, Testing of Induction motor – Various abnormal conditions, trouble shooting, faults, causes and remedies, Testing of Capacitor banks	**2**
5	**Special Tests for Faults Finding and Earthing:** Industrial Sonography (ultra sonic tests) to detect internal mechanical faults, Industrial X ray /Radiography, Megger, Heat Run Test, High voltage withstands Tests. Substation earthing system i) Types of earthing (Equipment and Neutral), Maintenance free earthing system. ii) Different electrode configuration (Plate and Pipe Electrode) iii) Tolerable step and Touch Voltages. Methods of testing earth resistance.	**2**
	Textbooks/Reference Books: 1. S. Rao, *Testing, Commissioning, Operation and Maintenance of Electrical Equipment*, Khanna Publishers, 1st Edition, 2010. 2. B.K.N. Rao, *Handbook of Condition Monitoring*, Elsevier Advanced Technology, Oxford (UK), 1st Edition, 1996. 3. S.L. Uppal, *Electrical Power*, Khanna Publishers, 15th Edition, 2010. 4. S.K. Shastri, *Preventive Maintenance of Electrical Apparatus*, Katson Publishing House, 1st Edition, 2003. 5. B.V.S. Rao, *Operation and Maintenance of Electrical Equipment*, Asia Publishing House, 1st Edition, 2004.	

Switchgear and Protection Lab		
Teaching Scheme Practical: 02Hr / Week Credit:01		**Examination Scheme** Internal Assessment: 20 Marks Mid-Sem Exam: 20 Marks End Sem Exam: 60 Marks
Unit	**Contents**	**Hrs.**
1	To analyze the operating characteristics and performance parameters of a fuse element under different fault conditions.	**2**
2	To evaluate the tripping characteristics and testing procedures of a Miniature Circuit Breaker (MCB).	**2**
3	To classify and examine the construction, working principles, and applications of various types of lighting arresters.	**2**
4	To investigate the Definite Minimum Time (DMT) characteristics of an overcurrent relay and assess its coordination in power system protection.	**2**
5	To perform testing and calibration of a static overvoltage relay for effective voltage protection.	**2**
6	To conduct performance analysis and testing of a static undervoltage relay in protective schemes.	**2**
7	To examine the operation and testing of a negative phase sequence protection relay in unbalanced fault conditions.	**2**
8	To analyze the principles and implementation of percentage differential protection for transformers.	**2**
9	To study the operational mechanism and fault detection capabilities of a Buchholz relay in transformer protection.	**2**
10	To assess the application and implementation of generator protection using the Merz-Price differential protection scheme.	**2**

<table>
<tr><th colspan="3">Electrical Machine Design Lab</th></tr>
<tr><td colspan="2">Teaching Scheme
Practical: 02Hr / Week
Credit:01</td><td>Examination Scheme
Internal Assessment: 20 Marks
Mid-Sem Exam: 20 Marks
End Sem Exam: 60 Marks</td></tr>
<tr><th>Unit</th><th>Contents</th><th>Hrs.</th></tr>
<tr><td>1</td><td>Symbols used in Electrical Engineering</td><td>2</td></tr>
<tr><td>2</td><td>Design and assembly of Choke with design report.</td><td>2</td></tr>
<tr><td>3</td><td>Design and assembly of Starter with design report</td><td>2</td></tr>
<tr><td>4</td><td>Design and layout of simplex lap winding (Detailed Drawing Sheet)</td><td>2</td></tr>
<tr><td>5</td><td>Design and layout of wave winding (Detailed Drawing Sheet)</td><td>2</td></tr>
<tr><td>6</td><td>Design and layout of ac lap winding (Detailed Drawing Sheet)</td><td>2</td></tr>
<tr><td>7</td><td>Design and assembly of transformers with design report. (Detailed Sheet for General Assembly of transformer)</td><td>2</td></tr>
<tr><td>8</td><td>Design and assembly of three phase induction Motor with design report. (Detailed Sheet for General Assembly of Induction Motor)</td><td>2</td></tr>
<tr><td>9</td><td>Complete any four drawings sheets with the help of Computer Aided Design Software like AUTOCAD)</td><td>2</td></tr>
</table>

Control System Lab

Teaching Scheme	Examination Scheme
Practical: 02Hr / Week Credit:01	Internal Assessment: 20 Marks Mid-Sem Exam: 20 Marks End Sem Exam: 60 Marks

Unit	Contents	Hrs.
1	Write a program to obtain: i. pole, zero and gain values from a given transfer function ii. Transfer function model from pole, zero, gain values.	2
2	Write a program to determine step & impulse response for a first order unity feedback system	2
3	Write a program to generate various standard test signals.	2
4	Write a program to plot the root locus for a given transfer function of the system using MATLAB.	2
5	Write a program to plot the Bode Plot for a given system using MATLAB.	2
6	Write a program to plot the Nyquist Plot for a given system using MATLAB.	2
7	Write a program to design Proportional, Proportional + Integral, Proportional+ Derivative and P-I-D Controller for second order system.	2
8	Write a program to determine step & impulse response for a second order unity feedback system	2
9	Write a program to determine state space model from transfer function model & vice versa.	2
10	Write a program to determine state space model from transfer function model & vice versa	2

Department of Electrical Engineering

Credit Framework under Four-Years UG Engineering Programme with Multiple Entry and Multiple Exit options:

- The Four-year Bachelor's Multidisciplinary Engineering Degree Programme allows the students to experience the full range of holistic and multidisciplinary education in addition to a focus on the chosen major and minors as per their choices and the feasibility of exploring learning from different institutions.

- The minimum and maximum credit structure for different levels under the Four-year Bachelor's Multidisciplinary Engineering UG Programme with multiple entry and multiple exit options are as given below:

Credit Framework

Levels	Qualification Title	Credit Requirements		Semester	Year
		Minimum	Maximum		
4.5	One Year UG Certificate in Engg./ Tech.	40	44	2	1
5.0	Two Years UG Diploma in Engg./ Tech.	80	88	4	2
5.5	Three Years Bachelor's Degree in Vocation (B. Voc.) or B. Sc. (Engg./ Tech.)	120	132	6	3
	4-Years Bachelor's degree				

- There are multiple exit options at each level. Student will be given a specific Qualification mentioned in the table depending on the level at which he/she decide to have an exit. Ex. If a student decides to exit after completion of two years (level 5.0) of the program, he will be given a Diploma in Engineering with specific exit condition mentioned in the syllabus of the specific branch. He/she can rejoin the program with the multiple entry option at the level next where he/she chose to exit previously. (Student can join at level 5.5 if successfully completed level 5.0 previously at the time of exit).
- Minimum credit requirements of each level are mentioned in the credit framework table.
- There are 4 distinct options available at level 6.0.
- First one is basic level 6.0 option where minimum 160-maximum 176 credits are mandatory which can be completed as per the Semester-wise Credit distribution structure mentioned in the table given below.

  Here, the Bachelor's Engineering Degree in chosen Engg./ Tech. Discipline with multidisciplinary minor (min.160-max.176 Credits) i.e. "**B. Tech in Electronics and Telecommunication Engineering with Computer Engineering**" (160-176 credits) enables students to take up five-six or required additional courses of 14 credits in the discipline other than Electronics and Telecommunication Engineering distributed over semesters III to VIII. Here in the case of "**B. Tech in Electronics and Telecommunication Engineering with Computer Engineering**" (160-176 credits) student is supposed to take up 50% or more courses to complete the 50% or more credits (from assigned 14 credits) from **Computer Engineering minor bucket**. The remaining courses to complete the assigned 14 credits can be covered from other discipline's minor buckets.

- Remaining three level 6.0 options are the advanced options where the student is given an opportunity to get extra qualification by earning some extra credits (18-20 extra credits). These three options are given below:

Levels	Qualification Title	Credit Requirements		Semester	Year
		Minimum	Maximum		
6.0	(B.E./ B.Tech. or Equivalent) in Engg./ Tech. with Multidisciplinary Minor	160	176	8	4
6.0	4-Years Bachelor's degree (B.E./ B.Tech. or Equivalent) in Engg./ Tech.- Honors and Multidisciplinary Minor	180	194	8	4
6.0	4-Years Bachelor's degree (B.E./ B.Tech. or Equivalent) in Engg./ Tech.- Honors with Research and Multidisciplinary Minor	180	194	8	4
6.0	4-Years Bachelor's degree (B.E./ B.Tech. or Equivalent) in Engg./ Tech.- Major Engg. Discipline with Double Minors (Multidisciplinary and Specialization Minors)	180	194	8	4

- Level 6.0: The **Bachelor's Engineering Degree with Honours** in chosen Major Engg./ Tech. Discipline i.e. in Electronics and Telecommunication Engineering with Honours with Multidisciplinary Minor (180-194 credits) enables students of Electronics and Telecommunication Engineering to take up five-six additional courses of 18 to 20 credits in the Electronics and Telecommunication Engineering discipline distributed over semesters III to VIII. The decision regarding the mechanism of distribution of these 18-20 credits over semesters III to VIII, which are over and above the min.160-max.176 Credits prescribed for the duration of four years will be taken by Academic Authorities of University. **Student must have CGPA equal to or greater than 7.5 at the end of second semester to go for this option**.
- Level 6.0: The **Bachelor's Engineering Degree with Research** in i.e. in Electronics and Telecommunication Engineering with Research with Multidisciplinary Minor (180-194 credits) enables students of Electronics and Telecommunication Engineering to take up a research project of 18 to 20 credits in the Electronics and Telecommunication Engineering discipline distributed over semesters VII to VIII. **Student must have CGPA equal to or greater than 7.5 at the end of sixth semester to go for this option**.
- Level 6.0: The **Bachelor's Engineering Degree in chosen Engg./ Tech. Discipline with Double Minor** (Multidisciplinary and Specialization Minor, 180-194 credits), i.e. "**B. Tech in Electronics and Telecommunication Engineering with *other selected discipline in* Engineering (as MDM) with Specialization Minor in Computer Engineering**" (180-194 credits) enables students to take up five-six additional courses of 14 credits in the discipline other than Electronics and Telecommunication Engineering(for completion of multidisciplinary minor) and 18 to 20 extra credits in the **Computer Engineering discipline** distributed over semesters III to VIII. Here, the ***other selected discipline* in Engineering should be different from Specialization Minor i.e. Computer Engineering**. This enables students to take up five-six or required additional courses of 18 to 20 credits in the **Computer Engineering** discipline distributed over semesters III to VIII, which are over and above the min.160-max.176 Credits. The decision regarding the mechanism of distribution of these 18-20 credits over semesters III to VIII, prescribed for the duration of four years will be taken by Academic Authorities of University. **Student must have CGPA equal to or greater than 7.5 at the end of second semester to go for this option**.
- Students need to follow the Semester-wise Credit distribution structure for Four Year UG Engineering Program as prescribed in the table given above.
- There are seven vertical categories with specific credits distributed in specific semesters.
- Student can choose a Program Elective Course (PEC) in that specific semester from the given subjects.
- Multidisciplinary courses (MDM) and Open Elective (OE) courses can be chosen from the MDM and OE Buckets depending on students choice. Completion of total credits given in the last column of the table for each vertical is mandatory.
- Students can complete 40% of the courses through online platforms like NPTEL/SWAYAM. The NPTEL SWAYAM course content should be at least 80% similar to the course content in the syllabus

Semester-wise Credit distribution structure for Four Year UG Engineering Program - One Major, One Minor

Semester		I	II	III	IV	V	VI	VII	VIII	Total Credits
Basic Science Course	BSC/ESC	06-08	08-10		--	--	--	--	--	14-18
Engineering Science Course		10-08	06-04		--	--	--	--	--	16-12
Programme Core Course (PCC)	Program Courses	--	02	08-10	08-10	10-12	08-10	04-06	04-06	44-56
Programme Elective Course (PEC)		--	--	--	--	04	08	02	06	20
Multidisciplinary Minor (MD M)	Multidisciplinary Courses		-	02	02	04	02	02	02	14
Open Elective (OE) Other than a particular program		--	--	04	02	02	--	--	--	08
Vocational and Skill Enhancement Course (VSEC)	Skill Courses	02	02	--	02	--	02	--	--	08
Ability Enhancement Course (AEC -01, AEC-02)	Humanities Social Science and Management (HSSM)	02	--	--	02	--	--	--	--	04
Entrepreneurship/Economics/ Management Courses		--		02	02	--	--	--	--	04
Indian Knowledge System (IKS)			02		--	--	--	--	--	02
Value Education Course (VEC)		--	--	02	02	--	--	--	--	04
Research Methodology	Experiential Learning Courses	--	--	--	--	--	--		04	04
Comm. Engg. Project (CEP)/Field Project (FP)		--	--	02	--	--	--	-	-	02
Project		--	--	--	--	--	--		04	04
Internship/ OJT		--	---			--	--	12	-	12
Co-curricular Courses (CC)	Liberal Learning Courses	02	02		--	--	--	--	-	04
Total Credits (Major)		**20-22**	**20-22**	**20-22**	**20-22**	**20-22**	**20-22**	**20-22**	**20-22**	**160-176**

General Rules and Regulations

1. The normal duration of the course leading to B.Tech degree will be EIGHT semesters.
2. The normal duration of the course leading to M.Tech. degree will be FOUR semesters.
3. Each academic year shall be divided into 2 semesters, each of 20 weeks duration, including evaluation and grade finalization, etc. The Academic Session in each semester shall provide for at least 90 Teaching Days, with at least 40 hours of teaching contact periods in a five to six days session per week. The semester that is typically from Mid-July to November is called the ODD SEMESTER, and the one that is from January to Mid-May is called the EVEN SEMESTER. Academic Session may be

scheduled for the Summer Session/Semester as well. For 1st year B. Tech and M. Tech the schedule will be decided as per the admission schedule declared by Government of Maharashtra.

4. The schedule of academic activities for a Semester, including the dates of registration, mid-semester examination, end-semester examination, inter-semester vacation, etc. shall be referred to as the Academic Calendar of the Semester, which shall be prepared by the Dean (Academic), and announced at least TWO weeks before the Closing Date of the previous Semester.

5. The Academic Calendar must be strictly adhered to, and all other activities including co-curricular and/or extra -curricular activities must be scheduled so as not to interfere with the Curricular Activities as stipulated in the Academic Calendar.

Registration:

1. Lower and Upper Limits for Course Credits Registered in a Semester, by a Full- Time Student of a UG/PG Programme:
   A full time student of a particular UG/PG programme shall register for the appropriate number of course credits in each semester/session that is within the minimum and maximum limits specific to that UG/PG programme as stipulated in the specific Regulations pertaining to that UG/PG programme.
2. Mandatory Pre-Registration for higher semesters: In order to facilitate proper planning of the academic activities of a semester, it is essential for the every institute to inform to Dean (Academics) and COE regarding details of total no. of electives offered (Course-wise) along with the number of students opted for the same. This information should be submitted within two weeks from the date of commencement of the semester as per academic calendar.
3. PhD students can register for any of PG/PhD courses and the corresponding rules of evaluation will apply.
4. Under Graduate students may be permitted to register for a few selected Post Graduate courses, in exceptionally rare circumstances, only if the DUGC/DPGC is convinced of the level of the academic achievement and the potential in a student.

Course Pre-Requisites:

1. In order to register for some courses, it may be required either to have exposure in, or to have completed satisfactorily, or to have prior earned credits in, some specified courses.
2. Students who do not register on the day announced for the purpose may be permitted LATE REGISTRATION up to the notified day in academic calendar on payment of late fee.
3. REGISTRATION IN ABSENTIA will be allowed only in exceptional cases with the approval of the Dean (Academic) / Principal.
4. A student will be permitted to register in the next semester only if he fulfills the following conditions:
   i) Satisfied all the Academic Requirements to continue with the programme of Studies without termination
   ii) Cleared all Institute, Hostel and Library dues and fines (if any) of the previous semesters;
   iii) Paid all required advance payments of the Institute and hostel for the current semester;
   iv) Not been debarred from registering on any specific ground by the Institute.

Evaluation System:

1. Absolute grading system based on absolute marks as indicated below will be implemented from academic year 2023-24, from I year B. Tech.

Percentage of marks	Letter Grade	Grade Point
91-100	EX	10.0
86-90	AA	9.0
81-85	AB	8.5
76-80	BB	8.0
71-75	BC	7.5
66-70	CC	7.0
61-65	CD	6.5
56-60	DD	6.0
51-55	DE	5.5
40-50	EE	5.0
<40	EF	0.0

2. Class is awarded based on CGPA of all eighth semester of B.Tech Program.

CGPA for pass is minimum 5.0	
CGPA upto <5.50	Pass class
CGPA ≥ 5.50&<6.00	Second Class
CGPA ≥ 6.00&<7.5	First Class
CGPA >7.50	Distinction
[Percentage of Marks =CGPA*10.0]	

3. A total of 100 Marks for each theory course are distributed as follows:

Mid Semester Exam (MSE) Marks	20
Continuous Assessment Marks	20
End Semester Examination(ESE)Marks	60

4. A total of 100 Marks for each practical course are distributed as follows

1.	Continuous Assessment Marks	40
2.	End Semester Examination (ESE)Marks	60

- It is mandatory for every student of B. Tech to score a minimum of 40 marks out of 100, M. Tech to score a minimum of 45 marks out of 100 with a minimum of 20 marks out of 60 marks in End Semester Examination for theory course.
- This will be implemented from the first year of B. Tech starting from Academic Year 2023-24

5. Description of Grades

EX Grade: An 'EX' grade stands for outstanding achievement.
EE Grade: The 'EE' grade stands for minimum passing grade.
The students may appear for the remedial examination for the subjects he/she failed for the current semester of admission only and his/her performance will be awarded with EE grade only.
If any of the students remain absent for the regular examination due to genuine reason and the same will be verified and tested by the Dean (Academics) or committee constituted by the University Authority.
FF Grade: The 'FF' grade denotes very poor performance, i.e. failure in a course due to poor performance .The students who have been awarded 'FF' grade in a course in any semester must repeat the subject in next semester.

6. Evaluation of Performance

a. Semester Grade Point Average (SGPA)

The performance of a student in a semester is indicated by Semester Grade Point Average (SGPA) which is a weighted average of the grade points obtained in all the courses taken by the student in the semester and scaled to a maximum of 10. (SGPI is to be calculated up to two decimal places). A Semester Grade Point Average (SGPA) will be computed for each semester as follows:

$$SGPA = \frac{[\sum_{i=1}^{n} c_i g_i]}{[\sum_{i=1}^{n} c_i]}$$

Where
'n' is the number of subjects for the semester,
'c_i' is the number of credits allotted to a particular subject, and
'g_i' is the grade-points awarded to the student for the subject based on his performance as per the above table.

SGPA will be rounded off to the second place of decimal and recorded as such.

b. Cumulative Grade Point Average (CGPA):

An up to date assessment of the overall performance of a student from the time he entered the Institute is obtained by calculating Cumulative Grade Point Average (CGPA) of a student. The CGPA is weighted average of the grade points obtained in all the courses registered by the student since s/he entered the Institute. CGPA is also calculated at the end of every semester (upto two decimal places).Starting from the first semester at the end of each semester (S), a Cumulative Grade Point Average (CGPA) will be computed as follows:

$$CGPA = \frac{[\sum_{i=1}^{m} c_i g_i]}{[\sum_{i=1}^{m} c_i]}$$

Where,
'm' is the total number of subjects from the first semester onwards up to and including the semester S,
'ci' is the number of credits allotted to a particular subject, and

'gi' is the grade-points awarded to the student for the subject based on his/her performance as per the above table.
CGPA will be rounded off to the second place of decimal and recorded as such.

7. **Attendance Requirements:**

   a. All students must attend every lecture, tutorial and practical classes.

   b. To account for approved leave of absence (eg. representing the Institute in sports, games or athletics; placement activities; NCC/NSS activities; etc.) and/or any other such contingencies like medical emergencies, etc., the attendance requirement shall be a minimum of 75% of the classes actually conducted. If the student failed to maintain 75% attendance, he/she will be detained for appearing the successive examination. The Dean (Academics)/ Principal is permitted to give 10% concession for the genuine reasons as such the case may be. In any case the student will not be permitted for appearing the examination if the attendance is less than 65%.

   c. The course instructor handling a course must finalize the attendance 3 calendar days before the last day of classes in the current semester and communicate clearly to the students by displaying prominently in the department and also in report writing to the head of the department concerned.

   d. The attendance records are to be maintained by the course instructor and he shall show it to the student, if and when required.

8. **Transfer of Credits:**

   The courses credited elsewhere, in Indian or foreign University/Institutions/ Colleges/Swayam Courses by students during their study period at DBATU may count towards the credit requirements for the award of degree. The guidelines for such transfer of credits are as follows:

   a. 20 % of the total credit will be considered for respective calculations.
   b. Credits transferred will be considered for overall credits requirements of the programme.
   c. Credits transfer can be considered only for the course at same level i.e UG, PG etc.
   d. A student must provide all details (original or attested authentic copies) such as course contents, number of contact hours, course instructor /project guide and evaluation system for the course for which he is requesting a credits transfer. He shall also provide the approval or acceptance letter from the other side. These details will be evaluated by the concerned Board of Studies before giving approval. The Board of Studies will then decide the number of equivalent credits the student will get for such course(s) in DBATU. The complete details will then be forwarded to Dean for approval.
   e. A student has to get minimum passing grades/ marks for such courses for which the credits transfers are to be made.
   f. Credits transfers availed by a student shall be properly recorded on academic record(s) of the student.
   g. In exceptional cases, the students may opt for higher credits than the prescribed.