VEERMATA JIJABAI TECHNOLOGICAL INSTITUTE (VJTI)
MATUNGA, MUMBAI 400 019

(Autonomous Institute affiliated to University of Mumbai)

Curriculum
(Scheme of Instruction & Evaluation)

For
Undergraduate Programme Leading to
Bachelor of Technology (B. Tech.) Degree
in
Electrical Engineering

Implemented from the batch admitted in Academic Year 2023-24
[NEP 2020 based Syllabus]

Program Educational Objectives (PEOs)

Electrical Engineering Graduates will have ability to

- Face technological challenges in the area of Electrical Engineering and ICT.
- Demonstrate expertise to articulate and use for problem solving, analysis design and evolution of electrical and electronics devices and systems.
- Develop leadership, team building and leadership skill**s.**

Program Outcomes (POs)

Engineering Graduates will be able to:

- **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
- **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.
- **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.
- **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.
- **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
- **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.
- **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.
- **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
- **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

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

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

- **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.

Program Specific Outcomes (PSOs)

Electrical Engineering Graduates will be able to

- Critically understand the generation, transmission and distribution concepts of Electrical Power Systems and its control.

- Gain in-depth knowledge to handle/control various electrical machines/drives used in industry.

Credit Framework for UG Programme in Electrical Engineering (Level 5.5- B. Voc. or B. Sc. (Tech.)) - Semester – V

Sr.	Course Code	Course Name	L	T	P	Hr	Cr	Examination Weightage in %			Ownership
								TA	MST	ESE	
1	R5EE3010T	Power System Analysis	3	0	0	3	3	20	30	50	Electrical
2	R5EE3011T	Power Electronics	3	0	0	3	3	20	30	50	Electrical
3	R5EE3012T	Microprocessor and Microcontrollers	3	0	0	3	3	20	30	50	Electrical
4	R5EE3013T	Control Systems for Electrical Engineers	3	0	0	3	3	20	30	50	Electrical
5	R5EE31XXT	Program Elective –I	3	1	0	4	4	20	30	50	Electrical
6	R5XX32XXT	Multi-disciplinary Minor-III	3	0	0	3	3	20	30	50	Electrical
7	R5EE3010L	Computer-Aided Power System Analysis Laboratory	0	0	2	2	1	ISCE: 60		40	Electrical
8	R5EE3011L	Power Electronics Laboratory	0	0	2	2	1	ISCE: 60		40	Electrical
9	R5EE3012L	Microprocessor and Microcontrollers Laboratory	0	0	2	2	1	ISCE: 60		40	Electrical
10	R5HS3403	Entrepreneurship / Economics / Management	2	0	0	2	2	ISCE: 60		40	Humanities
		Total	**20**	**1**	**6**	**27**	**24**				

Credit Framework for UG Programme in Electrical Engineering (Level 5.5- B. Voc. or B. Sc. (Tech.)) - Semester – VI

Sr.	Course Code	Course Name	L	T	P	Hr	Cr	Examination Weightage in %			Ownership
								TA	MST	ESE	
1	R5EE3015T	Electrical Drives	3	0	0	3	3	20	30	50	Electrical
2	R5EE3016T	Power System Protection	3	0	0	3	3	20	30	50	Electrical
3	R5EE31XXT	Program Elective – II	3	0	0	3	3	20	30	50	Electrical
4	R5EE31XXT	Program Elective – III	3	1	0	4	4	20	30	50	Electrical
5	R5XX32XXT	Multi-disciplinary Minor-IV	3	0	0	3	3	20	30	50	Electrical
6	R5XX33XXT	Open Elective – I	3	1	0	4	4	20	30	50	Electrical
7	R5HS3404	Entrepreneurship / Economics / Management	2	0	0	2	2	ISCE: 60		40	Humanities
8	R5EE3015L	Electrical Drives Laboratory	0	0	2	2	1	ISCE: 60		40	Electrical
9	R5EE31XXL	Program Elective – II Laboratory	0	0	2	2	1	ISCE: 60		40	Electrical
		Total	**20**	**2**	**4**	**26**	**24**				

Program Elective – I (Sem V)

R5EE3101T	Advanced Electronic Devices
R5EE3102T	Renewable Energy Resources
R5EE3103T	Basics of Communication Engineering
R5EE3104T	Applied Linear Algebra

Program Elective – II (Lab; Sem VI)

R5EE3105T	Digital Electronics
R5EE3106T	Wave Theory and Radiating Systems
R5EE3107T	Sensors & Transducers
R5EE3108T	Internet of Things

Program Elective – III (Sem VI)

R5EE3109T	Energy Management and Costing
R5EE3110T	Optimization Techniques
R5EE3111T	Substation Engineering
R5EE3112T	Restructured Power Systems

Program Elective – IV (Lab, Sem VII)

R5EE4113T	Robotics and Automation
R5EE4114T	High Voltage Engineering
R5EE4115T	Applied Digital Signal Processing
R5EE4116T	Advanced Control Systems

List of Exit Courses after completion of Semester V and VI

1. The exit option is available for students who have earned a total of 132 credits at the End of the Sixth Semester.
2. Student who wants to avail of the exit option after the third year have to earn an additional 6-8 credits from the list of courses shown below.
3. These courses students have to complete within summer vacation after 3rd Year.
4. After fulfillment as mentioned in 1 to 3 above, Students can earn B. Voc. or B. Sc. (Tech.) and the same will be issued by the Institute.

List of Exit Courses after completion of Semester V and VI: Electrical Engineering										
Sr.	**Course Code**	**Course Name**	**L**	**T**	**P**	**Hr**	**Cr**	**Examination Weightage in %**		
								TA	MST	ESE
1	R5EE3902I	Project / Mini-Project	0	0	12	12	6	ISCE :60		40
2	R5EE3907L	Industrial Automation Lab	0	0	4	4	2	ISCE: 60		40
3	R5EE3908L	Image and Video Processing Lab	0	0	4	4	2	ISCE: 60		40
4	R5EE3909L	Advanced Communication Systems Lab	0	0	4	4	2	ISCE: 60		40

Credit Framework for UG Programme in Electrical Engineering (Level 6.0 - B.Tech. In Electrical Engineering with Multidisciplinary Minor) - Semester – VII

Sr.	Course Code	Course Name	L	T	P	Hr	Cr	Examination Weightage in %			Ownership
								TA	MST	ESE	
1	R5EE4017T	AIML and Powergrids	3	0	0	3	3	20	30	50	Electrical
2	R5EE4018T	Digital Signal Processing	3	0	0	3	3	20	30	50	Electrical
3	R5EE41XXT	Program Elective –IV	3	0	0	3	3	20	30	50	Electrical
4	R5XX42XXT	Multi-disciplinary Minor-V	3	1	0	4	4	20	30	50	Electrical
5	R5XX43XXT	Open Elective – II	3	1	0	4	4	20	30	50	Electrical
6	R5EE4019L	Advanced Power System Laboratory	0	0	2	2	1	ISCE: 60		40	Electrical
7	R5EE4020L	Electrical Simulation Laboratory	0	0	2	2	1	ISCE: 60		40	Electrical
8	R5EE41XXL	Program Elective – IV Laboratory	0	0	2	2	1	ISCE: 60		40	Electrical
9	R5EE4801P	Project	0	0	8	8	4	ISCE: 60		40	Electrical
		Total	**15**	**2**	**14**	**31**	**24**				

Credit Framework for UG Programme in Electrical Engineering (Level 6.0 - B.Tech. In Electrical Engineering with Multidisciplinary Minor) - Semester – VIII

Sr.	Course Code	Course Name	L	T	P	Hr	Cr	Examination Weightage in %			Ownership
								TA	MST	ESE	
1	R5EE4701I	Internship	-	-	-	-	12	ISCE: 60		40	Electrical
2	R5EE4014T	Research Methodology (Online)	2	0	0	2	2	20	30	50	Electrical
		Total	**2**	**0**	**0**	**2**	**14**				

SEMESTER V SYLLABUS

	B. TECH. IN ELECTRICAL ENGINEERING	THIRD YEAR SEM - V				
COURSE CODE	R5EE3010T	CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL HRS	TOTAL CREDITS
		3	-	-	3	3
COURSE TITLE	POWER SYSTEM ANALYSIS	EVALUATION SCHEME				
		TA	MST	ESE	TOTAL MARKS	
		20	30	50	100	

Prerequisite

1. Elements of Power System
2. Basic Electrical Engineering
3. Electrical Machines
4. Electromagnetic Field Theory

COURSE OUTCOMES

Students should be able to:

1. Analyse power system for both steady state and dynamic conditions.
2. Analyse steady state power systems with Power flow study and Economic Dispatch.
3. Analyse stability for steady state, dynamic and large disturbances.
4. Model and design load frequency control loop and voltage control loop.

COURSE CONTENTS	
MODULE I	BASICS OF POWER SYSTEMS
	Generator model, transformer model, transmission system model, load Models. Primitive Network, Methods for formation of Y-Bus matrix.
MODULE II	POWER FLOW ANALYSIS
	Importance of power flow analysis in planning and operation of power systems. Statement of power flow problem, Classification of buses Development of Power flow model in complex variables form and polar variables form. Gauss-Seidel method and Newton-Raphson (N-R) method. Development of Fast Decoupled Power Flow (FDPF). DC Power Flow Analysis, Comparison of different methods. Regulation of transformers.
MODULE III	ECONOMIC DISPATCH
	Economic dispatch, neglecting generator limits and line losses, Economic dispatch with generator limits, Economic dispatch with line losses.
MODULE IV	AUTOMATIC GENERATION AND VOLTAGE CONTROL

	Load Frequency control (Single area case), Load Frequency Control and Economic Dispatch Control, Automatic Voltage Control, LFC with Generation Rate Constraints , speed governor dead- band and its effect on AGC.
MODULE V	**POWER SYSTEM STABILITY**
	Importance of stability analysis in power system, classification of power system stability, Analysis of rotor angle stability for small-signal and large-signal (transient), Single Machine Infinite Bus (SMIB) system, swing equation, equal area criterion, determination of critical clearing angle and time by using modified Euler method. Factors affecting steady state and transient stability and methods of improvement.

TEXT BOOKS

1. "Modern Power System Analysis", by Kothari & Nagrath, Tata McGraw Hill.
2. "Power System Analysis", by Hadi Sadat, Tata McGraw Hill.
3. "Power System Stability and Control" by Prabha Kundur, McGraw Hill.

REFERENCE BOOKS

1. "Power System Analysis", by Grainger and Stevenson, McGraw Hill
2. "Power System Analysis and Design", by J. D. Glover, M. S. Sharma & T. J. Overbye, Cengage Learning, 2012.
3. "Modern Power System Analysis", by Turan Gonen, CRC Press.

	B. TECH. IN ELECTRICAL ENGINEERING	THIRD YEAR SEM - V				
COURSE CODE	R5EE3010L	CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL HRS	TOTAL CREDITS
		0	0	2	2	1
COURSE TITLE	COMPUTER-AIDED POWER SYSTEM ANALYSIS LABORATORY	EVALUATION SCHEME				
		ISCE	ESE	TOTAL MARKS		
		60	40	100		

Prerequisite

1. Elements of Power System
2. Basic Electrical Engineering
3. Electrical Machines
4. Matlab Tool

COURSE OUTCOMES

Students should be able to:

1. Analyse power system for both steady state and dynamic conditions.
2. Analyse steady state power systems with Power flow study and Economic Dispatch.
3. Analyse stability for steady state, dynamic and large disturbances.
4. Model and design load frequency control loop and voltage control loop.

LIST OF EXPERIMENTS

1. Formation of Y-Bus Admittance Matrix Using the Direct Method
2. Formation of Y-Bus Admittance Matrix Using Singular Transformation Method With and Without Mutual Coupling
3. D.C. Power Flow Analysis
4. Power Flow Analysis Using Gauss-Seidel Iterative Method
5. Formulation of the Jacobian Matrix for Power Flow Analysis
6. Power Flow Analysis Using Newton-Raphson Method
7. Power Flow Analysis Using Fast Decoupled Load Flow Method
8. Economic Dispatch Problem Without Generator Limits
9. Economic Dispatch Problem With Generator Limits
10. Stability Analysis of Power Systems Using Euler Method and Modified Euler Method

	B. TECH. IN ELECTRICAL ENGINEERING	THIRD YEAR SEM - V				
COURSE CODE	R5EE3011T	CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL HRS	TOTAL CREDITS
		3	-	-	3	3
COURSE TITLE	POWER ELECTRONICS	EVALUATION SCHEME				
		TA	MST	ESE	TOTAL MARKS	
		20	30	50	100	

Prerequisite

1. Electrical Network
2. Basic Electrical and Electronics Engineering
3. Control system
4. MATLAB

COURSE OUTCOMES

Students should be able to:

1. Understand the operation of various power electronic devices.
2. Analyze the operation of various controlled converters.
3. Apply various phase controllers under different load conditions.
4. Understand and Analyze the operation of various inverters, choppers, and power supplies (DC and AC).

COURSE CONTENTS	
MODULE I	POWER ELECTRONICS DEVICES
	Construction, characteristics, ratings of Diode, SCR, IGBT, Power MOSFET. Application of these switches in controlling power (AC/DC).
MODULE II	CONTROLLED RECTIFIER
	Principle of Phase-Controlled Converter Operation, Single Phase Full Converters, with RL load, Single Phase Dual Converters, Principle of Three-Phase Half- Wave Converters, Three Phase Full Converters, Three Phase Full Converters with RL load, Three Phase Dual Converter, Power Factor Improvements, Extinction Angle Control, Symmetric Angle Control, PWM control, Single-Phase Sinusoidal PWM, Three Phase PWM Rectifier, Single Phase Semi-Converters with RL load, Three Phase Semi-Converters with RL load.
MODULE III	AC VOLTAGE CONTROLLERS
	Introduction, Principle of On-Off Control, Principle of Phase Control, Single Phase

	Bidirectional Controllers with Resistive Loads, Single Phase Controllers with Inductive Loads, AC voltage Controller with PWM Control.
MODULE IV	**INVERTERS**
	Principle of Operation, Performance parameters, Typical Inverters: series Inverters, Self commutated Inverters. Bridge Inverters, Three Phase Inverters, Current Source Inverters, Static Frequency Conversion, Voltage Control of Inverters, Harmonic neutralization of Inverters, PWM Inverters, Simple Application of Inverters with Motor load, Introduction to Multilevel Inverter.
MODULE V	**CHOPPER**
	Principle of Chopper operation, Step-up Chopper, Step-down Chopper, Step-up/ Step-down Chopper, Switching mode regulators – Buck, Boost, Buck-Boost and Cuk regulators, Bi-directional Chopper.
MODULE VI	**POWER SUPPLIES**
	DC Power Supplies, Switched-Mode DC Power Supplies, Flyback Converter, Forward Converter, Push-Pull Converter, Half Bridge Converter, Full Bridge Converter, Resonant DC Power Supplies, Bidirectional Power Supplies, AC Power Supplies, Switched Mode AC Power Supplies, Resonant AC Power Supplies, Bidirectional AC Power Supplies.

TEXT BOOKS

1. Rashid M. H., "Power Electronics-Circuits, Devices and Application", PHI Publication, second edition, 2001.
2. Mohan N., "Power Electronics- Converter Application and Design", Wiley Publication, third edition, 2002.
3. Power Electronics, P. S. Bimbra.

REFERENCE BOOKS

1. Bose B.K., "Modern Power Electronics and AC drives", Pearson Education Asia.

	B. TECH. IN ELECTRICAL ENGINEERING	THIRD YEAR SEM - V				
COURSE CODE	R5EE3011L	CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL HRS	TOTAL CREDITS
		0	0	2	2	1
COURSE TITLE	POWER ELECTRONICS LABORATORY	EVALUATION SCHEME				
		ISCE	ESE		TOTAL MARKS	
		60	40		100	

Prerequisite

1. Electrical Network
2. Basic Electrical and Electronics Engineering
3. Control system
4. MATLAB

COURSE OUTCOMES

Students should be able to:

1. Understand the operation of various power electronic devices.
2. Analyze the operation of various controlled converters.
3. Apply various phase controllers under different load conditions.
4. Understand and Analyze the operation of various inverters, choppers, cycloconverters, and power supplies (DC and AC).

LIST OF EXPERIMENTS

1. Single-Phase Diode-Bridge Rectifiers
2. Three-Phase Diode-Bridge Rectifiers
3. Step-Down (Buck) DC-DC Converters
4. Step-Up (Boost) DC-DC Converter
5. Full-Bridge DC-DC Converters
6. Simulation of single-phase Inverter with PWM control.
7. Parallel Operation of Inverters: Analysis and Simulation
8. Three-Phase PWM Inverters
9. Average Model of Three-Phase PWM Inverter

	B. TECH. IN ELECTRICAL ENGINEERING	THIRD YEAR SEM - V				
COURSE CODE	R5EE3012T	CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL HRS	TOTAL CREDITS
		3	-	-	3	3
COURSE TITLE	MICROPROCESSOR AND MICROCONTROLLERS	EVALUATION SCHEME				
		TA	MST	ESE	TOTAL MARKS	
		20	30	50	100	

Prerequisite

1. MATLAB
2. Fundamentals of C
3. Basic Programming
4. Digital logics

COURSE OUTCOMES

Student should be able to:

1. Compare various microprocessor / microcontroller architecture.
2. Use turbo debugger and other similar tool for assembly language programming
3. Develop assembly language programmes for 8086 and 8051 microcontroller
4 Design and implement 8051 based small application systems

COURSE CONTENTS	
MODULE I	**Microprocessor and Microcontroller Architecture**
	Introduction to Microprocessor/microcontroller, 8086 architectural features. 8051 architectural features, Overview of 8086 and MCS51 family, Memory organisation.
MODULE II	**8086 Hardware and programming**
	8086 Block Diagram and functions of each block, Minimum mode and maximum mode of 8086. Memory organisation, address decoding and interfacing of memory chips with 8086. Assembly language programming of 8086, Instructions: Data transfer, Arithmetic, Logical, Branching and special instructions. Peripheral IC interfacing 8255,8259,8279,8254. Interrupt structure of 8086 and subroutines.
MODULE III	**8051 Hardware & Programming**
	8051 Block Diagram and functions of each block. Internal and external Memory organisation, address decoding and interfacing of memory chips with 8051. SFR register banks bit addressable capability of 8051. Ports and pin functions of

	8051Instructions: Data transfer, Arithmetic, Logical, Branching and special instructions. Assembly language programming of 8051,
MODULE IV	**Features and use of 8051**
	I/O port structure and programming, Interrupts, Timer/Counter various modes of timer counters and programming, Serial port and programming.
MODULE V	**Interfacing & Applications**
	Display interfacing: 7-segment LED display, Keyboard interfacing: 4x4 matrix keyboard, Analog devices interfacing: 8-bit ADC/DAC, temperature sensor (LM35), Motor interfacing: Relay, dc motor, stepper motor and servo motor

TEXT BOOKS

1. "Microcomputer systems:the 8086/8088 family", By Yu Cheng Liu, Glenn A. Gibson Eastern Economy edition PHI
2. "Microprocessor & interfacing Programming& Hardware", Douglas V Hall Tata McGraw hill.
3. "The 8051 Microcontroller Architecture, Programming and applications" By Kenneth J Ayala Penram International.

REFERENCE BOOKS

1. "The 8086/8088 Family Design Programming and interfacing" by John Uffenbeck Eastern economy edition PHI.

	B. TECH. IN ELECTRICAL ENGINEERING	THIRD YEAR SEM - V				
COURSE CODE	R5EE3012L	CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL HRS	TOTAL CREDITS
		-	-	2	2	1
COURSE TITLE	MICROPROCESSOR AND MICROCONTROLLERS LAB	EVALUATION SCHEME				
		ISCE		ESE	TOTAL MARKS	
		60		40	100	

Prerequisite

1. MATLAB
2. Fundamentals of C
3. Basic Programming
4. Digital logics

COURSE OUTCOMES

Student should be able to:

1. Compare various microprocessor / microcontroller architecture.
2. Use turbo debugger and other similar tool for assembly language programming
3. Develop assembly language programmes for 8086 and 8051 microcontroller
4. Design and implement 8051 based small application systems

LIST OF EXPERIMENTS

1
- Program involving Data transfer instructions.
- Program involving Arithmetic and logic operations like addition and subtraction of multi precision numbers.

2 Multiplication and Division of signed and unsigned Hexadecimal numbers
- 16 Bit multiplication for unsigned numbers
- 8 Bit Division for Unsigned numbers
- 16 Bit Division for Unsigned numbers
- 16 Bit Division for Signed numbers

3 Code Conversion
- i) ASCII adjustment instructions
- ii) Binary to BCD code conversion
- iii) BCD to Binary code conversion

4 Arithmetic programs to find square, cube, LCM, GCD and factorial
- i) Program to find square and cube of a number
- ii) Program to find LCM of a given number
- iii) Program to find GCD of two numbers
- iv) Program to find factorial of a given number

5 Program involving bit manipulation instruction
   i) If given data is positive or negative
   ii) If given data is odd or even
   iii) Logical ones and zeros in a given data
   iv) Bit wise palindrome
   v) Nibble wise palindrome
6 Programs involving branch/loop instructions / programs on arrays
   i) addition of n numbers
   ii) program to subtract n numbers
   iii) program to find largest number among the series
   iv) program to find the largest number using dos display interrupts
   v) program to sort the numbers in ascending/descending order programs on string manipulation like string transfer, string reversing, searching for a character in a string and palindrome.
   vi) program for string transfer
   vii) program to reverse a string
   viii) program to search for a character in a string

	B. TECH. IN ELECTRICAL ENGINEERING	THIRD YEAR SEM - V				
COURSE CODE	R5EE3013T	CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL HRS	TOTAL CREDITS
		3	-	-	3	3
COURSE TITLE	CONTROL SYSTEMS FOR ELECTRICAL ENGINEERS	EVALUATION SCHEME				
		TA	MST	ESE	TOTAL MARKS	
		20	30	50	100	

Prerequisite

1. MATLAB
2. Fundamentals of Electrical Machines
3. Electrical Network
4. Signal System

COURSE OUTCOMES

Students should be able to:

1. Derive mathematical models of systems in the frequency & time domain.
2. Perform time domain analysis of systems. (Transient as well as steady state)
3. Sketch root locus of systems & perform stability analysis.
4. Perform stability analysis of systems using Bode & Nyquist plots.

COURSE CONTENTS	
MODULE I	REPRESENTATION OF SYSTEMS
	Definition of linear systems, causal systems, LTI systems, Non-linear Systems, Open loop and Closed loop Systems. Review of Laplace Transform; The Transfer function; Transfer Function of Electrical Networks. The general state-space representation of linear systems; converting the transfer function to state-space and vice-versa. Block diagram representation and reduction of feedback systems; Signal flow graphs, Mason's rule, Signal flow graphs of state equations.
MODULE II	TIME RESPONSE
	Definition of Poles, Zeros & System response; Response of First Order Systems, Response of Second Order Systems. Underdamped, Overdamped, Critically Damped and Undamped systems. System response with additional poles, System response with zeros; Laplace transform solution of state equations; Time domain solution of state equations.
MODULE III	STEADY STATE ERROR & STABILITY

	Steady state error for unity feedback systems; Static error constants and system type; Steady state error for disturbances; Steady state error for non-unity feedback systems; Sensitivity of control parameters. The notion of BIBO stability; Routh Hurwitz Stability Criterion; Special cases and Examples.
MODULE IV	**ROOT LOCUS TECHNIQUES**
	Introduction, Root locus plots, Summary of general rules for constructing Root-Loci, Root locus analysis for control systems, Root loci for systems with transport lag.
MODULE V	**FREQUENCY RESPONSE TECHNIQUES**
	Polar Plots, Bode Plots: Asymptotic Bode Plots, Underdamped Second-Order Transfer Functions, Error Constants from Bode Plots; Time-Delay Systems; Nyquist Criterion: Contour Mapping, Cauchy's Principle of the Argument, Stability of Feedback Systems, Application of the Nyquist Stability Criterion with Gain Adjustment. Relative Stability, Stability Margins, Stability Margins from Bode Plots, Relations between Frequency-Domain and Time-Domain Responses.

TEXT BOOKS

1. "Control System Engineering", Norman Nise, Seventh Edition. Wiley.
2. "Modern Control System Theory", M. Gopal, Wiley Eastern Ltd., New Delhi.
3. "Control Systems: An Introduction", Hassan K. Khalil, ECE Department, University of Michigan.

REFERENCE BOOKS

1. "Modern Control Systems", R.Bishop & R.Dorf, 8th edition(LPE),Addison Wesley,1998
2. "Modern Control Engineering" K. Ogata, Fourth Edition, Prentice Hall, 2010.

	B. TECH. IN ELECTRICAL ENGINEERING	THIRD YEAR SEM - V				
COURSE CODE	R5EE3101T	CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL HRS	TOTAL CREDITS
		3	1	-	4	4
COURSE TITLE	ADVANCED ELECTRONIC DEVICES	EVALUATION SCHEME				
		TA	MST	ESE	TOTAL MARKS	
		20	30	50	100	

Prerequisite

1. MATLAB
2. Fundamentals Semiconductor devices
3. Basic of Electrical and Electronics
4. Signal System

COURSE OUTCOMES

Students should be able to:

1. Analyze the working of Diodes and its applications
2. Analyze the working of Transistors and its applications.
3. Analyze the working of FET and its applications.
4. Analyze the working of operational amplifier and its applications.

COURSE CONTENTS	
MODULE I	SEMICONDUCTOR DIODE
	PN Junction diode small signal model, p-n junction under forward bias and reverse bias conditions, Rectifier Circuits, Clipping and Clamping circuits, Zener diode and its applications.
MODULE II	BIPOLAR JUNCTION TRANSISTORS
	Physical structure and operation modes, Active region operation of transistor, D.C. analysis of transistor circuits Biasing the BJT: Different type of biasing circuit and their analysis. Bias stability, Thermistor compensation, thermal runaway. Basic BJT amplifier configuration, Transistor as a switch. High frequency model of BJT amplifier. Effect of positive and negative feedback, advantages of negative feedback, Feedback Connection Type.
MODULE III	FIELD EFFECT TRANSISTORS
	Junction FET, its working and VI characteristic. Enhancement-type MOSFET: structure and physical operation, current voltage characteristics. Depletion-type MOSFET.JFET and MOSFET as an amplifier. Biasing in JFET and MOSFET amplifiers. Basic JFET and MOSFET amplifier configuration: common source,

	common gate and common drain types. High frequency model of FET, Low and High frequency response of common source amplifier.
MODULE IV	**POWER AMPLIFIER**
	Class A large signal amplifiers, Harmonic distortion, Transformer coupled audio power amplifier, Class B amplifier, Class AB operation, Power BJTs, Regulated power supplies, Series voltage regulator.
MODULE V	**OPERATION AMPLIFIER AND IT'S APPLICATIONS**
	Ideal Op-amp, Op-amp characteristics, Op-amp feedback analysis, Instrumentation amplifier, Oscillators.

TEXT BOOKS

1. J. Millman and C. C. Halkias, Integrated Electronics: Analog and Digital Circuits and Systems, Tata McGraw-Hill Publishing Company.
2. Donald A. Neamen, Electronic Circuit Analysis and Design, Tata McGraw-Hill.

REFERENCE BOOKS

1. Robert L. Boylestad, Louis Nashelsky, Electronic Devices and Circuit Theory, Eighth edition, PHI publishers.
2. Ramakant A. Gaikwad, Op-amp and Integrated circuits, Fourth edition, PHI Publication.

	B. TECH. IN ELECTRICAL ENGINEERING	THIRD YEAR SEM - V				
COURSE CODE	R5EE3102T	CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL HRS	TOTAL CREDITS
		3	1	-	4	4
COURSE TITLE	RENEWABLE ENERGY RESOURCES	EVALUATION SCHEME				
		TA	MST	ESE	TOTAL MARKS	
		20	30	50	100	

Prerequisite

1. MATLAB
2. Fundamentals of Semiconductor Devices
3. Basics of Electrical and Electronics
4. Fundamentals of Energy Conversion and Transformers

COURSE OUTCOMES

Students should be able to:

1. Analyze solar radiation patterns and the various technologies for harnessing solar energy.
2. Design solar PV panels and associated systems.
3. Calculate the generation of biomass, wind, and geothermal energy and the factors affecting it.
4. Demonstrate awareness of the impact of renewable sources in electrical system design and smart grid.

COURSE CONTENTS	
MODULE I	SOLAR CELL TECHNOLOGY
	Solar Spectrum, Extra-terrestrial radiation, Radiation on the earth surface, Global, diffuse solar radiation, Solar radiation at a given location, Daily radiation pattern, Annual variation in solar radiation, Optimal tilt for solar equipment, Monthly averaged global radiation at optimal tilt, Flat plate collectors, heat transfer processes, short term and long term collector performance, solar concentrators-design, analysis and performance evaluation. Si Wafer based solar cell technology: Development of commercial Si solar cells, high efficiency Si solar cells and other types of solar cell technologies. Thin Film Solar Cell Technologies: advantages, materials, common features, types of thin film cell technologies.
MODULE II	WIND ENERGY AND SYSTEM DESIGN
	Power plants utilizing wind energy technology, wind power conversion, turbine operation, and AC power conversion and grid integration through grid-tied (online) and standalone (offline) inverters. Understanding relevant grid codes for wind power connection, addressing voltage, frequency, reactive power requirements, and fault ride-through capabilities. Study of wind characteristics such as wind flow dynamics, vertical

	wind speed variation, and wind speed distribution. Analysis of power available in the wind, aerodynamic and mechanical aspects of different types of wind turbines, control strategies for efficient energy conversion. Site selection criteria including wind resource assessment, environmental impact, and logistical considerations. Wind turbine components, ratings, environmental surveys, parameter estimation for commissioning wind power stations, and economic analysis including cost estimation for wind power plants.
MODULE III	**SYSTEM DESIGN FOR SOLAR PV**
	Power plants incorporating solar cell technology, including DC power conversion, DC-AC power conversion, and grid connectivity using grid-tied (online) and standalone (offline) inverters. Understanding of relevant grid codes for solar power integration.
MODULE IV	**STORAGE DEVICES**
	Need for energy storage, conventional storage systems, and modern storage devices such as fuel cells, ultracapacitors, and their ratings. Overview of modern battery technologies, their applications, and the importance of battery management systems (BMS).
MODULE V	**INTEGRATION OF RENEWABLE AND FINANCIAL ESTIMATES**
	Impact of renewable energy sources in electrical system design, concept of green building, challenges in grid integration of renewable sources of energy, introduction to smart grid, costing and payback period.

TEXT BOOKS

1. "Renewable Energy Systems", Kaltschmitt, M.; Themelis, N.J.; Bronicki, L.Y.; Söder, L.; Vega, L.A. (Eds.) 3 volumes, 2013, XXVI, 1898 p.
2. "Introduction to Renewable Energy", Vaughn Nelson, West Texas A&M University, Canyon, USA Published: April 25, 2011 by CRC Press.

REFERENCE BOOKS

1. "Solar Energy - Principles of Thermal Collection and Storage",S. P. Sukhatme, Second Edition, Tata McGraw-Hil, New Delhi, 1996.
2. "Principles of Solar Engineering", Y. Goswami, F. Kreith and J. F. Kreider, Taylor and Francis, Philadelphia, 2000.
3. "Non conventional energy sources"B H Khan TataMc-Graw Hills Publication.

	B. TECH. IN ELECTRICAL ENGINEERING	THIRD YEAR SEM - V				
COURSE CODE	R5EE3103T	CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL HRS	TOTAL CREDITS
		3	1	-	4	4
COURSE TITLE	BASICS OF COMMUNICATION ENGINEERING	EVALUATION SCHEME				
		TA	MST	ESE	TOTAL MARKS	
		20	30	50	100	

Prereqisite

1. Basic analog and digital signal
2. Fundamental of communication system
3. Basic Electrical and Electronics system

COURSE OUTCOMES

Students should be able to:

1. Analyse the need of communication Systems.
2. Demonstrate and apply the techniques to reduce noise and interference in communication system.
3. Differentiate Analogue and Digital Communication System.
4. Describe various modulation techniques used in Analog and Digital communication system.
5. Describe the Modern communication network used in wired and wireless system.

COURSE CONTENTS	
MODULE I	BASICS OF COMMUNICATION SYSTEM
	Elements of a communication system, Types of signals, Block diagram, electromagnetic spectrum, modulation and demodulation, noise in communication system, types of noise, Signal-to-Noise ratio, noise factor and noise figure signal bandwidth and power, types of communication channels.
MODULE II	PRINCIPLE OF ANALOG COMMUNICATION SYSTEM
	Amplitude Modulation: Modulation and Demodulation Basic concept, signal representation, Spectrum, waveforms, modulation index, bandwidth, voltage distribution, and power calculation **Amplitude demodulation techniques:** Radio receivers Receiver characteristics, TRF and super heterodyne receivers, AM detectors. Diode detector, practical diode detector, and square law Detector DSBFC: Principles, modulating circuits, low level and high level transmitters DSB suppressed carrier:- Multiplier modulator, nonlinear modulator, and switching Modulator. **Single Side Band (SSB):**-Principle, filter method, phase shift method and third method, independent sideband (ISB) and Vestigial Side Band (VSB) principles and transmitters.

MODULE III	PHASE ANGLE AND FREQUENCY MODULATION
	Frequency Modulation (FM): Basic concept, mathematical analysis, frequency spectrum of FM wave, sensitivity, phase deviation and modulation index, frequency deviation andpercent modulated waves, bandwidth requirement of angle modulated waves, deviation ratio, narrow band FM, and wide band FM. **Modulator circuits:** Varactor diode modulator, FET reactance modulator. Direct FM transmitter, indirect FM Transmitter, noise triangle in FM, pre-emphasis and de-emphasis. Phase Modulation (PM): Principle and working of transistor direct PM modulator, relationship and comparison between FM and PM. **FM demodulation:** Balance slope detector, Foster-Seely discriminator, ratio detector, comparison between FM demodulators, comparison between AM, FM and PM. Applications of FM and PM.
MODULE IV	**PRINCIPLE OF DIGITAL COMMUNICATION SYSTEM**
	Sampling theorem for Low-pass and Band-pass signals, proof with spectrum, Aliasing. Sampling Techniques- Principle, generation, demodulation, spectrum. Quantization, Quantization error, Non-uniform quantizing Encoding. PCM, DPCM- transmission system, band width. ASK, PSK, and QPSK system. **Optical fibre communication:** Type of fibres, optical source, detectors, basic principle of optical communication system.

TEXT BOOKS

1. "Electronic Communications", by Dennis Roddy and John Coolen, PrenticeHall of India, 3rd Ed. 1992.
2. "Electronics Communications System", by Kennedy Davis, Fourth Edition, Mcgraw Hill Publication.
3. "Principles of communication systems", by Taub & Schlling, Tata McGraw Hill, Third edition 2007.

REFERENCE BOOKS

1. "Digital Communication", by John C. Proakis, McGraw Hill International, 1995.
2. "Data and computer communication", by William Stallings, Pearson Education, Tenth Edition, 2013.
3. "Communication Systems", by Haykin S John, Wiley & sons, Fifth Ed 2009.

	B. TECH. IN ELECTRICAL ENGINEERING	THIRD YEAR SEM - V				
COURSE CODE	R5EE3104T	CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL HRS	TOTAL CREDITS
		3	1	-	4	4
COURSE TITLE	APPLIED LINEAR ALGEBRA	EVALUATION SCHEME				
		TA	MST	ESE	TOTAL MARKS	
		20	30	50	100	

Prereqisite

1.Fundamentals of calculus
2.Fundamental of linear and nonliner mathematics
3.Basic linear algebra

COURSE OUTCOMES

Students should be able to:

1. Carry out operations on matrices to solve electrical engineering problems
2. Carry out operations involving systems of linear equations
3. Apply mathematical reasoning in several different areas of Electrical Engineering.

COURSE CONTENTS	
MODULE I	VECTOR SPACES
	Vector spaces, Subspaces, linear dependence, spanning sets, Basis, dimension, Four fundamental subspaces associated with a matrix, revisit the system of linear equations, Intersection and Sum of Subspaces, Direct Sums, Embedding of sub- spaces.
MODULE II	LINEAR TRANSFORMATIONS
	Definition, Matrix representations, Change of Basis, Similarity transformations, Invertible transformations.
MODULE III	INNER PRODUCTS
	Definition, induced norm, inequalities, Orthogonality, Gram-Schmidt orthogonalization process, Orthogonal projections, rank-one projections, Unitary transformations, isometry.
MODULE IV	POSITIVE DEFINITE MATRICES
	Minima, maxima, and saddle points; tests for positive definiteness; singular value decomposition; minimum principles; and the finite element method.

TEXT BOOKS

1. “Linear Algebra and its applications”, by Gilbert Strang, 4th Edition, Cengage Learning publications, 2007.
2. “Linear Algebra”, by Kenneth Hoffman and Ray Kunze, 2nd Edition, Pearson publication, 2015.

REFERENCE BOOKS

1. “Linear algebra and its applications”, by D. C. Lay, Pearson (3rd edition), 2014.
2. “Linear Algebra”, by S. H. Friedberg, A. J. Insel and L. E. Spence 4^{th} Edition, PHI, 2003.

SEMESTER VI SYLLABUS

	B. TECH. IN ELECTRICAL ENGINEERING	THIRD YEAR SEM - VI				
COURSE CODE	R5EE3015T	CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL HRS	TOTAL CREDITS
		3	-	-	3	3
COURSE TITLE	ELECTRIC DRIVES	EVALUATION SCHEME				
		TA	MST	ESE	TOTAL MARKS	
		20	30	50	100	

Prerequisite

1. Power Electronics
2. Electrical Machines
3. Control System

COURSE OUTCOMES

Students should be able to:

1. Select the appropriate electric motor and drive for an application
2. Employ various techniques for Induction motor control
3. Propose appropriate method of control for a DC machine and Synchronous machine
4. Employ and justify use of special machines for various applications

COURSE CONTENTS	
MODULE I	**Dynamics of Electric Drives**
	Fundamental torque equation, Multi-quadrant operation and speed torque conventions, steady state stability, load equalization, classes of duty and selection of motor.Heating and cooling curves for machines. Short time ratings of machines and their calculations
MODULE II	**Control of DC Motor**
	Starting and Braking methods, concepts of plugging, Speed control of DC Motors, Ward Leonard Drives, Phase Controlled DC Motor Drive, multi-quadrant operation, Chopper-controlled, DC drives, multi-quadrant operation. Modelling of Dc machine and calculations using parameters. Simulation using derived model.
MODULE III	**Induction Motor**
	Modelling of induction machine (Review), Starting and Braking methods, Scalar control of induction motor – Stator Voltage Control, Static Scherbius Drive, Principle of vector control and field orientation, Sensorless control and flux observers, Direct torque and flux control of induction motor.
MODULE IV	**Control of Induction Motor**

	Slip power recovery scheme, injection of slip power, variable frequency drives, Induction motor control using VSI and CSI, concept and need of VVFD.
MODULE V	**Control of Special Electric Machines**
	Permanent magnet synchronous motor, Brushless dc motor, Switched reluctance motor, Stepper motors and control.

TEXT BOOKS

1. B. K. Bose, "Modern Power Electronics and AC Drives", Pearson Education.
2. G.K. Dubey, "Fundamentals of Electrical Drives", Narosa Publication, 2001.
3. R. Krishnan, "Electric Motor Drives: Modeling, Analysis and Control", Prentice Hall

REFERENCE BOOKS

1. P. S. Bhimbra, "Generalized Theory of Electric Machines", Khanna Publication.
2. Rashid M. H, "Power Electronics - Circuits, Devices and Applications", Pearson Education

	B. TECH. IN ELECTRICAL ENGINEERING	THIRD YEAR SEM - VI				
COURSE CODE	R5EE3015L	CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL HRS	TOTAL CREDITS
		-	-	2	2	1
COURSE TITLE	ELECTRIC DRIVES LABORATORY	EVALUATION SCHEME				
		ISCE		ESE	TOTAL MARKS	
		60		40	100	

Prerequisite

1. Power Electronics
2. Electrical Machines
3. Control System
4. Matlab

COURSE OUTCOMES

Students should be able to:

1. Select the appropriate electric motor and drive for an application
2. Employ various techniques for Induction motor control
3. Propose appropriate method of control for a DC machine and Synchronous machine
4. Employ and justify use of special machines for various applications

LIST OF EXPERIMENTS

1. To perform rheostatic braking on three phase Induction Motor.
2. To perform rheostatic braking on D.C. Motor.
3. To perform plugging on three phase Induction Motor.
4. To perform plugging on D.C. Motor
5. To perform regenerative braking on three phase Induction Motor.
6. To perform retardation test on D.C. Motor to find out its Moment of inertia.
7. To study the starting and running characteristics of converter fed DC traction motor
8. To study the performance of VSI fed three-phase induction motor using PWM technique.
9. To control the speed of a three phase slip ring Induction motor using rotor impedance control.
10. To study the performance & control of a Stepper motor.
11. To Study the Performance of a permanent magnet Brushless dc motor drive.
12. To study the control & performance Characteristics of switched Reluctance motor.
13. To study vector control of 3 phase induction motor.
14. Simulation of at least 2-4 experiments using any simulation software.

	B. TECH. IN ELECTRICAL ENGINEERING	THIRD YEAR SEM - VI				
COURSE CODE	R5EE3016T	CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL HRS	TOTAL CREDITS
		3	0	-	3	3
COURSE TITLE	POWER SYSTEM PROTECTION	EVALUATION SCHEME				
		TA	MST	ESE	TOTAL MARKS	
		20	30	50	100	

Prerequisite
1. Power Electronics
2. Electrical Machines
3.Power system
4. Measuring Instruments

COURSE OUTCOMES

Students should be able to:

1. Explain the principle of circuit interruption in fuse and different types of circuit breakers.
2. Discuss performance of protective relays, components of protection scheme and relay terminology. Explain the working of overcurrent relays, differential and distance protection.
3. Discuss protection of generators, motors, Transformer and Bus Zone Protection.
4. Discuss principle of Numerical relays.

COURSE CONTENTS	
MODULE I	INTRODUCTION TO SWITCHGEAR AND POWER SYSTEM PROTECTION
	Sequence of operation and interlocking, Fuse, Isolators, Circuit breaker, Arc phenomena and arc extinction, type of CBs, Important terms related to circuit breakers, Auto-reclosure. Introduction to power system protection, its importance and objectives. Protection philosophy, attributes: reliability, selectivity, speed, sensitivity, security, dependability, accuracy. Protection zones, Backup protection, Instrumentation for Relaying: CTs, PTs and CVTs.
MODULE II	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.
MODULE III	DIFFERENTIAL PROTECTION

	Introduction, Differential Relays, Simple Differential Protection, Percentage or Biased Differential Relay.
MODULE IV	**DISTANCE PROTECTION**
	Introduction, Impedance Relay, Reactance Relay, Mho Relay, Angle Impedance Relay, Effect of Arc Resistance on the Performance of Distance Relays, Reach of Distance Relays. Effect of Power Swings on Performance of Distance Relays, Load Encroachment.
MODULE V	**PROTECTION OF GENERATOR, BUSBAR AND TRANSFORMER**
	Generator Protection: Types of fault in alternators, Protection against stator faults, Balanced earth fault protection, stator inter turn protection, loss of excitation, loss of prime mover. Transformer protection: Types of Faults in Transformers, Percentage Differential Protection of Transformers, Inrush Phenomenon, Percentage Differential Relay with Harmonic Restraint, High Resistance Ground Faults in Transformers, High Resistance Ground Faults on the Delta Side, High Resistance Ground Faults on the Star Side, Inter-turn Faults in Transformers, Incipient Faults in Transformers, Buchholz Relay, Protection Against Over-fluxing. Busbar Protection: Differential Protection of Busbars, Selection of CT Ratios for Busbar Protection.
MODULE VI	**Introduction to Numerical Relaying**
	Architecture, simultaneous sampling, Nyquist theorem and sampling frequency, Antialiasing filter, Phasor computation using DFT, Frequency estimation, DFT Leakage

TEXT BOOKS

1. "Fundamentals of Power System Protection", Y.G. Paithankar, S.R. Bhide, PHI Learning, 2010.
2. "Switchgear protection and power System", S. Rao, Khanna Publication.

REFERENCE BOOKS

1. "Power System Protection, Ram B and Vishwakarma D. N.", TMH, New Delhi
2. NPTEL course on Power System Protection by Prof. S. A. Soman, IIT Bombay and Prof. A. K. Pradhan, IIT Kharagpur.

	B. TECH. IN ELECTRICAL ENGINEERING	THIRD YEAR SEM - VI				
COURSE CODE	R5EE3105T	CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL HRS	TOTAL CREDITS
		3	0	-	3	3
COURSE TITLE	DIGITAL ELECTRONICS	EVALUATION SCHEME				
		TA	MST	ESE	TOTAL MARKS	
		20	30	50	100	

Prerequisite

1. Fundamentals of the number system
2. Basics of computers
3. Fundamentals of Electronics

COURSE OUTCOMES

Students should be able to:

1. Understand Number Systems and Boolean Algebra.
2. Analyze and Implement Digital Logic Gates and Families.
3. Apply Minimization Techniques for Logic Simplification.
4. Design and Develop Combinational and Sequential Circuits

COURSE CONTENTS	
MODULE I	NUMBER SYSTEMS, BASIC LOGIC GATES & BOOLEAN ALGEBRA
	Binary arithmetic and radix representation of different number systems. Sign and magnitude representation, fixed-point representation, and complement notation. Various codes (BCD, Gray, Excess-3, etc.), arithmetic operations in different codes, and their interconversion. Features and postulates of Boolean algebra, Boolean theorems, and Boolean functions. Derived logic gates: XOR, NAND, and NOR—block diagrams and truth tables. Conversion between Boolean expressions and logic diagrams. Universal logic gate realization and conversion between different logic representations (positive, negative, and mixed logic).
MODULE II	DIGITAL LOGIC GATE CHARACTERISTICS
	Characteristics and operation of TTL logic gates; Theory and operation of TTL NAND gate circuitry; Open collector TTL and three-state output logic; TTL subfamilies, MOS, and CMOS logic families; Realization of logic gates using RTL, DTL, ECL, CMOS, and MOSFET technologies; Interfacing different logic families.
MODULE III	MINIMIZATION TECHNIQUES

	Minterm and maxterm representation of Boolean functions. Karnaugh Map (K-map) method for simplification (up to 4 variables). Conversion of truth tables into SOP and POS forms. Handling of incompletely specified functions. Variable mapping and the Quine-McCluskey minimization technique.
MODULE IV	**COMBINATIONAL SYSTEMS**
	Design of combinational logic circuits, Adders and subtractors: half adder, full adder, binary serial and parallel adders, BCD adder, and binary multiplier. Decoders: binary to Gray code decoder, BCD to decimal, BCD to 7-segment decoder. Multiplexers and demultiplexers, encoders (Octal to binary, BCD to Excess-3). Diode switching matrix, Implementation of logic circuits using multiplexers, encoders, decoders, and demultiplexers.
MODULE V	**SEQUENTIAL SYSTEMS**
	Latches and flip-flops: R-S, D, J-K, and Master-Slave flip-flops. Conversion between different types of flip-flops. Counters: synchronous and asynchronous ripple counters, decade counters, modulus counters, skipping state counters, Counter design, state diagrams, and state reduction techniques. Ring counters and their applications Registers: buffer registers and shift registers.

TEXT BOOKS

1. Herbert Taub, Donald L. Schilling, Digital Integrated Electronics, TMH, 2008.
2. M. Morris Mano, Digital Logic and Computer Design, Pearson Edu., 2014.
3. A. Anandkumar, Fundamentals of Digital circuits, PHI, 2009.

REFERENCE BOOKS

1. Floyd, Digital Funadamentals, Pearson 2008 .
2. S. Salivahanan, Sarivazhagan, Digital circuit design, Vikas publications, 2009.

	B. TECH. IN ELECTRICAL ENGINEERING	THIRD YEAR SEM - VI				
COURSE CODE	R5EE3105L	CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL HRS	TOTAL CREDITS
		-	-	2	2	1
COURSE TITLE	DIGITAL ELECTRONICS LABORATORY	EVALUATION SCHEME				
		ISCE		ESE	TOTAL MARKS	
		60		40	100	

Prerequisite

1. Fundamentals of the number system
2. Basics of computers
3. Fundamentals of Electronics

COURSE OUTCOMES

Students should be able to:

1. Understand Number Systems and Boolean Algebra.
2. Analyze and Implement Digital Logic Gates and Families.
3. Apply Minimization Techniques for Logic Simplification.
4. Design and Develop Combinational and Sequential Circuits

LIST OF EXPERIMENTS

1. To verify the truth tables of basic logic gates: AND, OR, NOR, NAND, NOR. Also to verify the truth table of Ex-OR, Ex-NOR (For 2, 3, & 4 inputs using gates with 2, 3, & 4 inputs).
2. To verify the truth table of OR, AND, NOR, Ex-OR, Ex-NOR realized using NAND & NOR gates.
3. To realize an SOP and POS expression.
4. To realize Half adder/ Subtractor& Full Adder/ Subtractor using NAND & NOR gates and to verify their truth tables.
5. To realize a 4-bit ripple adder/ Subtractor using basic Half adder/ Subtractor& basic Full Adder/ Subtractor.
6. To verify the truth table of 4-to-1 multiplexer and 1-to-4 demultiplexer. Realize the multiplexer using basic gates only. Also to construct and 8-to-1 multiplexer and 1-to-8 demultiplexer using blocks of 4-to-1 multiplexer and 1-to-4 demultiplexer.
7. Design & Realize a combinational circuit that will accept a 2421 BCD code and drive a TIL - 312 seven segment display.
8. Using basic logic gates, realize the R-S, J-K and D-flip flops with and without clock signal and verify their truth table

9. Construct a divide by 2,4& 8 asynchronous counter. Construct a 4-bit binary counter and ring counter for a particular output pattern using D flip flop.
10. Perform input/output operations on parallel in/Parallel out and Serial in/Serial out registers using clock. Also exercise loading only one of multiple values into the register using multiplexer.

	B. TECH. IN ELECTRICAL ENGINEERING	THIRD YEAR SEM - VI				
COURSE CODE	R5EE3106T	CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL HRS	TOTAL CREDITS
		3	0	-	3	3
COURSE TITLE	WAVE THEORY AND RADIATING SYSTEMS	EVALUATION SCHEME				
		TA	MST	ESE	TOTAL MARKS	
		20	30	50	100	

Prerequisite

1. Fundamentals of EMFT
2. Fundamental of signal and system
3. Fundamentals of Electronics

COURSE OUTCOMES

Students should be able to:

1. Understand antenna principles and radiation of electromagnetic waves.
2. Derive the field equations for the basic radiating elements like linear wire antenna, loop antenna and helical antenna.
3. Analyze the basic antenna types such as microstrip antennas, horn antennas and reflector antennas.
4. Design of uniform linear and planar antenna arrays using isotropic and directional sources.
5. Understand electromagnetic wave propagation over ground, sky and space and apply wave theory in practical engineering problems related to communication and radar systems.

COURSE CONTENTS	
MODULE I	ANTENNA FUNDAMENTALS
	Helmholtz Equation, EM Radiation Mechanism, basic antenna parameters, Radiation pattern, radiation power density, radiation intensity, Beam width, directivity, Antenna efficiency, Gain, beam efficiency, bandwidth, polarization, input impedance, antenna vector effective length and equivalent areas, Antenna radiation efficiency, FRIIS transmission equation.
MODULE II	WIRE ELEMENTS: DIPOLES, MONOPOLES, LOOPS AND HELICAL
	Infinitesimal dipole, radiation fields, radiation resistance, radiation sphere, near field, far field directivity, small dipole, finite length dipole, half wave length dipole, linear elements near or on infinite perfect conductors, Monopole antenna, Folded dipole. Loop Antenna: Small circular loop, comparison of small loop with short dipole, Ferrite loop, radiation patterns its parameters and their application.

	Designing problem of loop antenna with single turn, multiple turn using practical aspects. Helical Antennas: Input impedance matching, Axial mode and normal mode propagation, Circular polarization using Helical Antenna.
MODULE III	**PATCH ANTENNA**
	Microstrip antenna (MSA): Introduction, Feeding Techniques, Regular Shape MSAs (Rectangular, Circular, Equilateral Triangular), Design of Regular shape MSAs, CMSA, TMSA etc.
MODULE IV	**APERTURE ANTENNAS**
	Horn Antennas: E-Plane Sectoral Horn, H-Plane Sectoral Horn, Pyramidal Horn, Conical Horn **Reflector Antennas:** Introduction, Plane Reflector, Corner Reflector, Parabolic Reflector, Design considerations.
MODULE V	**ANTENNA ARRAYS**
	Linear arrays, Array of two isotropic point sources, linear arrays of N elements, principle of pattern multiplication applicable to non- isotropic sources, Phase scanning arrays, broadside and End-fire Array, Calculations of Directivity, Beam width, Maxima and null directions for N-element Array. Introduction to planar and circular arrays. Design of Yagi antenna and Log Periodic antennas.
MODULE VI	**WAVE PROPAGATION AND EMERGING TRENDS**
	Wave Propagation: Ground Wave, Sky Wave and Space Wave Propagation. **Modern Applications:** Antennas in Wireless Communication, MIMO and Smart Antenna Systems, Metamaterials, Radar and Remote Sensing Applications.

TEXT BOOKS

1. C. A. Balanis, Antenna Theory: Analysis and Design (3rd eds.), John Wiley & Sons, Hoboken, NJ, 2005.
2. J.D. Kraus, R.J. Marhefka, A.S. Khan―Antennas & Wave Propagation, McGraw Hill Publications, 4th Edition,2011.
3. G. Kumar, K. P. Ray, Broadband Microstrip Antenna, Artech House, 2002.

REFERENCE BOOKS

1. Stutzman, Theile, Antenna Theory and Design, John Wiley and Sons, 3rd Edition.
2. R.E. Collin, Antennas and Radio Wave Propagation, International Student Edition, McGraw Hill.

	B. TECH. IN ELECTRICAL ENGINEERING	THIRD YEAR SEM - VI				
COURSE CODE	R5EE3106L	CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL HRS	TOTAL CREDITS
		-	-	2	2	1
COURSE TITLE	WAVE THEORY AND RADIATING SYSTEMS LABORATORY	EVALUATION SCHEME				
		ISCE		ESE	TOTAL MARKS	
		60		40	100	

Prerequisite

1. Fundamentals of EMFT
2. Fundamental of signal and system
3. Fundamentals of Electronics
4. Matlab

COURSE OUTCOMES

Students should be able to:

1. Design and Analyze Wire antennas.
2. Design and Study Antenna Arrays.
3. Develop antennas for modern applications.

LIST OF EXPERIMENTS

1. To simulate the radiation pattern of a dipole antenna in EM Simulation software.
2. To plot the radiation pattern of a half wave dipole/monopole antenna.
3. To study and plot the radiation pattern of Loop Antenna.
4. To study and plot the radiation pattern of Yagi-Uda Antenna.
5. To study and plot the radiation pattern of Log Periodic Antenna.
6. To study and plot the radiation pattern of Microstrip Antenna.
7. To study and plot the radiation pattern of Array Antenna and study pattern multiplication.
8. To simulate 5G antenna array on FEM simulation tool.
9. To simulate metamaterial inspired structures in FEM simulation tool.
10. To analyze the various performance parameters of antennas using VNA.

	B. TECH. IN ELECTRICAL ENGINEERING	THIRD YEAR SEM - VI				
COURSE CODE	R5EE3107T	CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL HRS	TOTAL CREDITS
		3	0	-	3	3
COURSE TITLE	SENSORS AND TRANSDUCERS	EVALUATION SCHEME				
		TA	MST	ESE	TOTAL MARKS	
		20	30	50	100	

Prerequisite

1. Fundamentals of measurement and instruments
2. Basic Electrical and Electronics system

COURSE OUTCOMES

Students should be able to:

1. Analyse Different types of Transducers
2. Apply principles of optical sensing techniques
3. Select Appropriate velocity and acceleration sensors.
4. Analyse the operation of flow, temperature and acoustic sensors.

COURSE CONTENTS	
MODULE I	SENSOR FUNDAMENTALS AND CHARACTERISTICS
	Definition, classification, Error analysis, Static and dynamic characteristics of transducers, Performance measures of sensors.
MODULE II	OPTICAL SOURCES AND DETECTORS
	Electronic and Optical properties of semiconductor as sensors, LED, Semiconductor lasers, Fiber optic sensors, Thermal detectors, Photo multipliers, photoconductive detectors, Photo diodes, Avalanche photodiodes, CCDs.
MODULE III	INTENSITY POLARIZATION AND INTERFEROMETRIC SENSORS
	Intensity sensor, Microbending concept, Interferometers, Mach Zehnder, Michelson, FabryPerot and Sagnac, Phase sensor: Phase detection, Polarization maintaining fibers.
MODULE IV	VELOCITY AND ACCELERATION SENSORS
	Electromagnetic velocity sensor, Doppler with sound, light, Accelerometer characteristics, capacitive, piezo-resistive, piezoelectric accelerometer, thermal accelerometer, rotor, monolithic and optical gyroscopes.
MODULE V	FLOW, TEMPERATURE AND ACOUSTIC SENSORS

	Flow sensors: pressure gradient technique, thermal transport, ultrasonic, electromagnetic and Laser anemometer. microflow sensor, coriolis mass flow and drag flow sensor. Temperature sensors- thermoresistive, thermoelectric, semiconductor and optical. Piezoelectric temperature sensor. Acoustic sensorsmicrophones-resistive, capacitive, piezoelectric, fiber optic, solid state - electrect microphone.
MODULE VI	**APPLICATIONS OF SENSORS AND TRANSDUCERS**
	Use of Sensors for specific application. Condition based monitoring using sensors and transducers. Case study of sensors/transducer applications.

TEXT BOOKS

1. "Sensor and Actuators", Patranabis D, Prentice Hall of India (Pvt) Ltd., 2006.
2. "Sensor and Transducers", Ian Sinclair, Elsevier India Pvt Ltd, 3rd Edition, 2011.
3. "A Course in Electrical and Electronic Measurements and Instrumentation", Sawhney. A.K., Puneeth Sawhney, Dhanpat Rai Publications, 2012.

REFERENCE BOOKS

1. "Measurement System, Application and Design", Ernest O. Doeblin, Tata McGraw Hill Publishing Company Ltd., 5th Edition, 2008.
2. "Optical Fiber Communications", Gerd Keiser, 5th edition, McGraw-Hill Science, Delhi, 2017
3. "Measurement, Instrumentation and sensor Handbook", 2017, 2nd edition, John G Webster, CRC Press, Florida.
4. "Fiber optic sensors: An introduction for engineers and scientists", Eric Udd and W.B. Spillman, 2013, 2nd edition, Wiley, New Jersey.
5. "Fundamentals of photonics", Bahaa E. A. Saleh and Malvin Carl Teich, 2012, 1st edition, John Wiley, New York.

	B. TECH. IN ELECTRICAL ENGINEERING	THIRD YEAR SEM - VI				
COURSE CODE	R5EE3107L	CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL HRS	TOTAL CREDITS
		-	-	2	2	1
COURSE TITLE	SENSORS AND TRANSDUCERS LABORATORY	EVALUATION SCHEME				
		ISCE		ESE	TOTAL MARKS	
		60		40	100	

Prerequisite

1. Fundamentals of measurement and instruments
2. Basic Electrical and Electronics system

COURSE OUTCOMES

Students should be able to:

1. Describe the concepts of sensor calibration, error analysis and signal conditioning.
2. Explain the fundamental principles of operation for various types of sensors and transducers.
3. Design and develop sensors with desired properties.
4. Create analytical design and development solutions for sensors.

LIST OF EXPERIMENTS

1. Analyse and quantify different types of errors in sensor measurement.
2. Study the relationship between light intensity and photo diode current.
3. Demonstrate the principle of micro-bending in optical fibers for sensing application.
4. Study an electromagnetic velocity sensor's relationship between rotational speed and output voltage.
5. Measure acceleration using a piezoelectric accelerometer and analyse its response to vibrations.
6. Measure temperature using a thermocouple and understand the Seebeck effect.
7. Measure flow rate in a pipe using a differential pressure sensor.
8. Condition monitoring using vibration sensors.
9. Design and implement a complete sensor-based system for a specific application

	B. TECH. IN ELECTRICAL ENGINEERING	THIRD YEAR SEM - VI				
COURSE CODE	R5EE3108T	CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL HRS	TOTAL CREDITS
		3	0	-	3	3
COURSE TITLE	INTERNET OF THINGS	EVALUATION SCHEME				
		TA	MST	ESE	TOTAL MARKS	
		20	30	50	100	

Prerequisite

1. Fundamental skills of programming
2. Basic principle of instruments

COURSE OUTCOMES

Students should be able to:

1. Apply principles of IoT in global context.
2. Use Devices, Gateways and Data Management in IoT.
3. Build state of the art architecture in IoT.
4. Design small applications of IoT in Industrial and Commercial Building Automation.

COURSE CONTENTS	
MODULE I	INTRODUCTION TO IOT
	Defining IoT, Characteristics of IoT, Physical design of IoT, Logical design of IoT, Functional blocks of IoT, Communication models & APIs.
MODULE II	IOT& M2M
	Machine to Machine, Difference between IoT and M2M, Software Define Network.
MODULE III	NETWORK & COMMUNICATION ASPECTS
	Wireless medium access issues, MAC protocol survey, Survey routing protocols, Sensor deployment & Node discovery, Data aggregation & dissemination.
MODULE IV	IOT APPLICATIONS FOR VALUE CREATIONS
	Introduction, IoT applications for industry: Future Factory Concepts, Brownfield IoT, Smart Objects, Smart Applications, Four Aspects in your Business to Master IoT, Value Creation from Big Data and Serialization, IoT for Retailing Industry, IoT for Oil and Gas Industry, Opinions on IoT Application and Value for Industry, Home Management, eHealth.
MODULE V	DEVELOPING IOTS

	Introduction to Python, Introduction to different IoT tools, developing applications through IoT tools, developing sensor based application through embedded system platform, Implementing IoT concepts with python.
MODULE VI	**INTERNET OF THINGS PRIVACY, SECURITY AND GOVERNANCE**
	Design challenges, Development challenges, Security challenges, Other challenges, Introduction, Overview of Governance, Privacy and Security Issues, Contribution from FP7 Projects, Security, Privacy and Trust in IoTData-Platforms for Smart Cities, First Steps Towards a Secure Platform, Smartie Approach. Data Aggregation for the IoT in Smart Cities, Security.

TEXT BOOKS

1. Internet of Things: A Hands-On Approach, by Vijay Madisetti, Arshdeep Bahga.
2. Rethinking the Internet of Things: A Scalable Approach to Connecting Everything", by Francis daCosta, 1 st Edition, Apress Publications, 2013.

REFERENCE BOOKS

1. Fundamentals of Wireless Sensor Networks: Theory and Practice, by Waltenegus Dargie, Christian Poellabauer.

	B. TECH. IN ELECTRICAL ENGINEERING	THIRD YEAR SEM - VI				
COURSE CODE	R5EE3108L	CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL HRS	TOTAL CREDITS
		-	-	2	2	1
COURSE TITLE	INTERNET OF THINGS LABORATORY	EVALUATION SCHEME				
		ISCE		ESE	TOTAL MARKS	
		60		40	100	

Prerequisite

1. Fundamental skills of programming
2. Basic principle of instruments
3. Embedded, Resberry ,Aurdino Uno

COURSE OUTCOMES

Students should be able to:

1. Apply principles of IoT in global context.
2. Use Devices, Gateways and Data Management in IoT.
3. Build state of the art architecture in IoT.
4. Design small applications of IoT in Industrial and Commercial Building Automation.

LIST OF EXPERIMENTS

1. Introduction and study of Eclipse IoT Project.
2. List and summarize few Eclipse IoT Projects.
3. Sketch the architecture of IoT Toolkit and explain each entity in brief.
4. Demonstrate a smart object API gateway service reference implementation in IoT toolkit.
5. Write and explain working of an HTTP- to-CoAP semantic mapping proxy in IoT toolkit.
6. Use of gateway-as-a-service deployment in IoT toolkit.
7. Study of application framework and embedded software agents for IoT toolkit.
8. Working of Raspberry Pi.

	B. TECH. IN ELECTRICAL ENGINEERING	FINAL YEAR SEM - VI				
COURSE CODE	R5EE3109T	CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL HRS	TOTAL CREDITS
		3	1	-	4	4
COURSE TITLE	ENERGY MANAGEMENT AND COSTING	EVALUATION SCHEME				
		TA	MST	ESE	TOTAL MARKS	
		20	30	50	100	

Prerequisite

1. Fundamental knowledge of electrical and mechanical systems
2. Basic concept of energy audit
3. Fundamentals of management

COURSE OUTCOMES

Students should be able to:

1. Identify energy-saving opportunities in electrical power distribution and mechanical systems.
2. Implement an energy conservation program for HVAC, pumps, compressors, DGs, Illumination Boilers, Furnaces, etc.
3. Formulate and implement the method of auditing energy.
4. Calculate various energy efficiency and performance parameters for industrial, residential and commercial loads.

COURSE CONTENTS	
MODULE I	INTRODUCTION
	Energy conservation in the compressor, HVAC, refrigeration, fans and blowers, types of pumps, system characteristics, pump curves, EC opportunities, and cooling. Tower, efficient operation, flow control strategies, DG set systems- selection, installation and operational factor, energy saving measures, energy efficiency. Calculations and case studies in thermal utilities such as boilers, steam systems, furnaces, refractors, and the need for and benefits of cogeneration and waste heat recovery. Schemes, case studies.
MODULE II	BASICS OF ENERGY AND ITS LAWS
	Basics of Energy and its various forms: Electricity basics - DC & AC currents, Electricity tariff, Load management and Maximum demand control, Power factor. Material and Energy balance: Facility as an energy system, Methods for preparing process flow, Material and energy balance diagrams.
MODULE III	IMPACT OF ENERGY ON THE ENVIRONMENT
	Commercial and Non-Commercial Energy, Primary Energy Resources, Commercial Energy Production, Final Energy Consumption, Energy Needs of Growing Economy, Long Term Energy Scenario, Energy Pricing, Energy Sector Reforms, Energy and

	Environment: Air Pollution, Climate Change, Energy Security, Energy Conservation and its Importance, Energy Strategy for the Future, Energy ConservationAct-2001 and its Features.
MODULE IV	**ENERGY AUDIT**
	Energy Management & Audit: Definition, Energy audit-need, Types of energy audit, Energy management (audit) approach-understanding energy costs, Benchmarking, Energy performance, Matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution, Energy audit instruments.

TEXT BOOKS

1. "Energy for a sustainable world", by Jose Goldenberg, Thomas Johansson, A.K.N. Reddy.
2. "Energy policy", by B.V. Desai, Robert Williams, Wiley Eastern Ltd.
3. "Modeling approach to long term demand and energy implication", by J.K. Parikh, Martinus Nijhoff Publishers.

REFERENCE BOOKS

1. "Energy Efficiency in Thermal Utilities", Guidebook for National Certification Examination for Energy.

	B. TECH. IN ELECTRICAL ENGINEERING	FINAL YEAR SEM - VI				
COURSE CODE	R5EE3110T	CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL HRS	TOTAL CREDITS
		3	1	-	4	4
COURSE TITLE	OPTIMIZATION TECHNIQUES	EVALUATION SCHEME				
		TA	MST	ESE	TOTAL MARKS	
		20	30	50	100	

Prerequisite

1. Advanced level of mathematics
2. MATLAB Fundamentals
3. Probability Theory

COURSE OUTCOMES

Students should be able to:

1. Translate descriptive statements of the design engineering problems into an optimization problem.
2. Apply Analytical and Numerical methods for Single & Multivariate Nonlinear Programming Problems.
3. Apply the Simplex Method for Linear Programming Problems.
4. Apply Exterior Penalty Function Method for Constrained Optimization Techniques for Nonlinear Programming Problems

COURSE CONTENTS	
MODULE I	INTRODUCTION TO OPTIMIZATION:
	1.1 Definition and meaning of optimization, need of optimization. 1.2 Optimization problem formulation: statement of optimization Problem. 1.3 Terminology: design vector, objective function, objective function surface, design constraints, constraint surface. 1.4 Classification of optimization problem.
MODULE II	NONLINEAR PROGRAMMING PROBLEMS—CLASSICAL OPTIMIZATION TECHNIQUES AND BASIC CONCEPTS
	2.1 Analytical One-dimensional (Single Variable) Unconstrained Optimization: local and global minima, local and global maxima, necessary and sufficient condition of single optimization with no constraints. 2.2 Analytica Multi-dimensional (Multivariate) Unconstrained Optimization: necessary and sufficient condition of multivariate Optimization with no constraints.

	2.3 Analytical Multidimensional Optimization with Equality Constraints: Direct Substitution Method, Lagrange Multipliers Method. 2.4 Analytical Multidimensional Optimization with Inequality Constraints: Kuhn—Tucker Conditions for Solving Multivariable Inequality Constrained Problems.
MODULE III	**NUMERICAL METHODS FOR UNCONSTRAINED OPTIMIZATION OF SINGLE VARIABLE & MULTIVARIABLE NONLINEAR PROGRAMMING PROBLEMS**
	3.1 Distinction between Analytical and Numerical Methods, unimodal and multimodal function. 3.2 Numerical Methods for Single Variable Nonlinear Programming Problems: Elimination Methods, Unrestricted Search, Interval Halving Method, Fibonacci Search, Golden Section Search Method, Interpolation Methods—Quadratic Interpolation 3.3 Numerical Methods for Multivariable Variable Nonlinear Programming Problems: Univariate Method, Hooke—Jeeves Pattern Search Method, Powell's Pattern Search Method, Indirect Search Methods, Cauchy's Steepest Descent Method, Fletcher—Reeves Method, Newton's Method.
MODULE IV	**SIMPLEX METHOD FOR LINEAR PROGRAMMING PROBLEMS**
	4.1 Definition of linear programming problem (LPP), standard form of LPP. 4.2 Simplex method, Big-M method, two-phase simplex method. 4.3 Duality in linear programming – standard primal LP problem, dual LP Problem.
MODULE V	**CONSTRAINED OPTIMIZATION TECHNIQUES FOR NONLINEAR PROGRAMMING PROBLEMS**
	5.1 Structure of Constrained Nonlinear Programming Problems. 5.2 Exterior Penalty Function Method

TEXT BOOKS

1. Jasbir S. Arora, Introduction to Optimum Design, 3rd Edition, Academic Press- 2012.
2. Ashok D. Belegundu, Optimization concepts and applications in Engineering, Pearson Education, 2002.

REFERENCE BOOKS

1. S. S. Rao, Optimization, 3rd Enlarged Edition, New Age International (P) Ltd., Publishers, New Delhi, 2010.
2. Kalyanmoy Deb, “Optimization for Engineering Design”, Prentice Hall of India (P) Ltd., New Delhi, 1998.

	B. TECH. IN ELECTRICAL ENGINEERING	FINAL YEAR SEM - VI				
COURSE CODE	R5EE3111T	CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL HRS	TOTAL CREDITS
		3	1	-	4	4
COURSE TITLE	SUBSTATION ENGINEERING	EVALUATION SCHEME				
		TA	MST	ESE	TOTAL MARKS	
		20	30	50	100	

Prerequisite

1. Fundamentals of Engineering drawing
2. Fundamentals of power systems
3. Fundamentals of Electrical Network
4. PLC Programming

COURSE OUTCOMES

Students should be able to:

1. Describe the primary consideration in the process of substation design
2. Outline the working principles of substation switching equipment
3. Explain the different types of bus configurations
4. Design criteria of substation grounding and protection
5. Illustrate the substation communication (SCADA)

COURSE CONTENTS	
MODULE I	INTRODUCTION
	Background, Needs Determination, Budgeting, Financing, Traditional and Innovative Substation Design, Site Acquisition, Design, Construction and Commissioning Process.
MODULE II	HIGH VOLTAGE SWITCHING EQUIPMENT
	Ambient conditions, Disconnect switches, Load Break switches, high-speed grounding switches, power fuses, circuit switches, circuit breakers, and GIS substations.
MODULE III	TYPES OF SUBSTATIONS & BUS/SWITCHING CONFIGURATIONS
	Transmission substation, distribution substation, collector substation, switching substations, gas-insulated substations, air-insulated substations, bus configurations: single bus, double bus, double break, main and transfer bus, double bus, single breaker, ring bus, break-and-a-half, Comparison of configurations.
MODULE IV	DESIGN OF SUBSTATION GROUNDING AND PROTECTION
	Reasons for substation grounding system, accidental ground circuit, Design criteria Touch and step voltage, soil resistivity, grid resistance, grid current, use of the design

	equations, selection of conductors, grounding fence, and other design considerations. Lightning stroke protection-lightning parameters, empirical design methods: substation fire protection-Fire hazards, fire protection measures, fire protection selection criterion.
MODULE V	**SUBSTATION AUTOMATION AND COMMUNICATIONS**
	Introduction, components of substation automation system, automation applications, protocol fundamentals, supervisory control and data acquisition (SCADA) historical perspective, SCADA functional requirements, SCADA communication requirements, components of SCADA system, SCADA communication protocols, the structure of a SCADA communication protocol, security for substation communications, security methods, security assessment.

TEXTBOOKS

1. John D. McDonald, Electrical Power Substation Engineering, CRC Press, 2nd Edition, 2001.
2. R. S. Dahiya, VinayAttri," Sub-Station Engineering Design & Computer Applications" S K Kataria and Sons Publications, 1st Edition, 2013.

REFERENCE BOOKS

1. P. S. Satnam, P. V. Gupta, "Substation Design and Equipment" Dhanapat Rai Publications, 1st Edition, 2013.
2. Turan Gonen, "Electric Power Distribution Engineering" CRC press, third edition, 2014.

	B. TECH. IN ELECTRICAL ENGINEERING	THIRD YEAR SEM - VI				
COURSE CODE	R5EE3112T	CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL HRS	TOTAL CREDITS
		3	1	-	4	4
COURSE TITLE	RESTRUCTURED POWER SYSTEMS	EVALUATION SCHEME				
		TA	MST	ESE	TOTAL MARKS	
		20	30	50	100	

Prerequisite

1. Power system advanced level
2. Electrical Machine

COURSE OUTCOMES

Students should be able to:

1. Analyse different market structures.
2. Apply basic concepts of economics to power market, different market mechanisms, competition and market power
3. Formulate peculiarities of electricity as a commodity, models for competition and trading in the electricity sector.
4. Justify the need of ancillary services, ancillary services for supply-demand balance, voltage control and black-start, procurement of ancillary services.

COURSE CONTENTS	
MODULE I	INTRODUCTION TO RESTRUCTURING
	Background, overview of the restructured power industry, unbundling of power system players and the associated issues
MODULE II	BASIC CONCEPTS FROM ECONOMICS
	Fundamentals of Markets, Producers and Consumers models, opportunity cost , Demand and supply functions, Market Equilibrium, Pareto Efficiency, Global Welfare and Dead Weight, Time varying prices, Costs, Risk, Type of Markets, Perfect and Imperfect Markets, Monopoly.
MODULE III	MARKETS FOR ELECTRICITY
	Peculiarities of electricity as a commodity, Trading periods, Bilateral or Decentralized Trading, Centralized Trading, Market Clearing Price, Recovering the fixed costs, Gate closure, Settlement Process, Piecewise linear cost curves, Imperfect competition: Bertrand Model and Cournot Model.

MODULE IV	TRANSMISSION NETWORKS AND ELECTRICITY MARKETS
	Decentralized Trading over a Transmission Network, Centralized Trading over a Transmission Network, Unconstrained Transmission, Constrained Transmission, Economic Dispatch, Congestion Surplus, Nodal Pricing/ Locational Marginal Pricing, Mathematical Formulation of Nodal Pricing, Financial Transmission Rights.
MODULE V	**ANCILLARY SERVICES**
	Definition of ancillary services, ancillary services for supply-demand balance, voltage control and black-start, procurement of ancillary services.

TEXT BOOKS

1. "Fundamentals of Power System Economics", by Daniel Kirschen and GoranStrbac, John Wiley & Sons Ltd "Electrical Power Trading", by Sally Hunt, Wiley Finance.
2. "Electrical Power Trading", by Sally Hunt, Wiley Finance.

REFERENCE BOOKS

1. "Restructured Power Systems", by Mohammad Shahidehpour and Muwaffaq Alomoush, Marcel Dekker, INC.

	B. TECH. IN ELECTRICAL ENGINEERING	THIRD YEAR SEM - VI				
COURSE CODE	R5EE3301T	CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL HRS	TOTAL CREDITS
		3	1	-	4	4
COURSE TITLE	ELECTRICAL SAFETY AND DISASTER MANAGEMENT	EVALUATION SCHEME				
		TA	MST	ESE	TOTAL MARKS	
		20	30	50	100	

Prerequisite

1. Power system advanced level
2. Electrical Machine

COURSE OUTCOMES

Students should be able to:

1. Identify electrical hazards and risks associated with industrial, commercial, and residential electrical systems.
2. Apply safety measures and protection techniques such as grounding, circuit breakers, and PPE to prevent electrical accidents.
3. Demonstrate knowledge of disaster management and emergency response for electrical fires, shocks, and other hazards.
4. Interpret and comply with safety regulations and standards like IEEE, NFPA, OSHA, and Indian Electricity Rules.

COURSE CONTENTS	
MODULE I	INTRODUCTION TO ELECTRICAL SAFETY
	Fundamentals of electrical hazards, Types of electrical accidents: Shock, burns, arc flash, electrocution. Effects of electric current on the human body. Safety standards and regulations (IEC, OSHA, IEEE, NFPA 70E). Personal protective equipment (PPE) in electrical systems.
MODULE II	ELECTRICAL PROTECTION SYSTEMS
	Electrical grounding and earthing principles. Circuit breakers, fuses, and surge protection devices. Residual current devices (RCDs) and ground fault circuit interrupters (GFCIs). Overcurrent, overvoltage, and insulation protection. Safe work practices in electrical installations and maintenance.
MODULE III	INDUSTRIAL AND WORKPLACE ELECTRICAL SAFETY

	Lockout procedures, Electrical safety in high-voltage and low-voltage installations. Hazardous locations and intrinsically safe equipment. Risk assessment and safety audits. Case studies on industrial electrical accidents.
MODULE IV	**DISASTER MANAGEMENT AND EMERGENCY RESPONSE**
	Types of disasters: Natural and man-made disasters. Electrical fire hazards and fire prevention techniques. Role of first aid in electrical shock and burns. National and international disaster management frameworks.
MODULE V	**SAFETY REGULATIONS, STANDARDS, AND ETHICS**
	National Electrical Code (NEC) and Indian Electricity Rules. Environmental and sustainability aspects of electrical safety. Legal and ethical considerations in electrical safety. Role of engineers in disaster risk reduction.

TEXT BOOKS

1. R. K. Rajput, "A Textbook of Electrical Safety", Laxmi Publications ISBN: 978-8131803824.
2. John Cadick, Mary Capelli-Schellpfeffer, Dennis Neitzel, and Al Winfield, "Electrical Safety Handbook (5th Edition)", McGraw-Hill Education.
3. B. E. Prasad and Y. K. Singh, "Disaster Management", A. P. H. Publishing Corporation.

REFERENCE BOOKS

1. Ray A. Jones and Jane G. Jones, "Electrical Safety in the Workplace", Jones & Bartlett Learning.
2. S. L. Goel, "Disaster Administration and Management: Text and Case Studies", Deep & Deep Publications.