MALNAD COLLEGE OF ENGINEERING, HASSAN

(An Autonomous Institution Affiliated to VTU, Belgaum)

Autonomous Programmes

Bachelor of Engineering

DEPARTMENT OF

ELECTRICAL & ELECTRONICS ENGINEERING

SYLLABUS

V and VI Semesters

(3rd Year)

Academic Year 2022-23

VISION

To Develop Pool of Knowledge, Skills and Facilities, and Impart High Quality Education.

MISSION

To adopt modern instructional methods.

To accomplish a sustained up gradation of Infrastructure.

To ensure total understanding & commitment to the set objectives.

To formulate interactive programmes with Industries and Universities of repute.

To utilize the in house expertise for activities to fulfil the social obligations.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO1: Developing a strong base in the domain of electrical electronics and information sciences to excel in professional career.

PEO2: Promoting the interest for higher studies and continued lifelong learning.

PEO3: Imbibing confidence to take up diverse career paths including entrepreneurship.

PEO4: Encouraging team works with effective communication, Inculcating leadership, professional-ethical qualities and fulfil social obligations.

PROGRAM OUTCOMES

Engineering Graduates 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 commit to professional ethics and responsibilities and norms of the engineering practice.

9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, 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, make effective presentations, and give and receive clear instructions.

11. **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.

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.

PROGRAM SPECIFIC OUTCOMES (PSOs)

Upon graduation, students with a degree B.E. in Electrical & Electronics Engineering will be able to:

1. Develop models, design, analyse and assess the performance of different types of electrical machines, control systems and generation, transmission, distribution, protection mechanisms in power systems.
2. Demonstrate knowledge and hands-on competence in the application of circuit analysis and design, associated software and applications, analog and digital electronics and microcontrollers to build, test, operate and maintain electrical and electronics systems.

Scheme of Evaluation (Theory Courses)

Assessment	Marks
CIE 1	15
CIE 2	10
CIE 3	15
Activities (Quiz/Assignment/Mini Project) Minimum 2	10
SEE	50
Total	**100**

Scheme of Evaluation (Laboratory Courses)

Assessment	Marks
Continuous internal Evaluation in every lab session by the Course coordinator	30
Laboratory CIE conducted by the Course coordinator	20
SEE	50
Total	**100**

Examination	Maximum Marks	Minimum Marks to Qualify
CIE	50	20
SEE	50	20

V Semester					
Course Code	**Course Category**	**Course Title**	**L-T-P**	**Credits**	**Contact hours**
20EE501	PC-15	Linear Control Systems	3-1-0	4	5
20EE502	PC-16	Power Electronics	2-2-0	4	4
20EE503	PC-17	Engineering Electromagnetics	4-0-0	4	4
20EE504	PC-18	Power System Analysis & Stability	3-1-0	4	5
20EE505	PC-19	Switchgear Protection & Distribution	3-0-0	3	3
20EE506	PC-20	Digital Signal Processing	3-0-0	3	3
20EE507	PC-21	Microcontroller Laboratory	0-0-1.5	1.5	3
20EE508	PC-22	DC& Synchronous Machines Laboratory	0-0-1.5	1.5	3
19ENV	HSM-5	Environmental Science (Mandate Audit Course)	2-0-0	-	2
19AAD	HSM-6	Analytical Ability Development (Mandate Audit Course)	0-1-0	1	2
		Total Credits		25	34

VI Semester					
Course Code	**Course Category**	**Course Title**	**L-T-P**	**Credits**	**Contact hours**
20EE601	PC-23	Modern control Theory	3-1-0	4	5
20EE602	PC-24	Computer Methods in Power Systems	3-1-0	4	5
20EE603	PC-25	Electrical Machine Design	3-1-0	4	5
20EE604	PC-26	Power Electronics Laboratory	0-0-1.5	1.5	3
20EE605	PC-27	Control Systems Laboratory	0-0-1.5	1.5	3
20EE6XX	PE-1	ELECTIVE-I	3-0-0	3	3
20EE6XX	PE-2	ELECTIVE-II	3-0-0	3	3
19OEXXXX	OE-1	Open Elective - 1	3-0-0	3	3
HSM-7	19ARD	Aptitude Reasoning Development (Mandate Audit Course)	0-0-0	-	2
HSM-8	19CIP	Constitution of India & Professional Ethics (Mandate Audit Course)	0-0-0	-	2
PE	19SW61	SWAYAM Course-1 (Mandate Audit Course)	-	-	-
		Total Credits		**24**	**34**

Elective - 1					
Course Code	**Course Category**	**Course Title**	**L-T-P**	**Credit s**	**Contact hours**
20EE611	PE-1	Testing & Commissioning of Electrical Equipments	3-0-0	3	3
20EE612	PE-1	Special Electrical Machines	3-0-0	3	3
20EE613	PE-1	Electronic Instrumentation Techniques	3-0-0	3	3
20EE614	PE-1	Smart Grid Technologies	3-0-0	3	3
20EE615	PE-1	Programmable Logic Controllers	3-0-0	3	3
Elective – II					
20EE621	PE-2	Object Oriented Programing with C++	3-0-0	3	3
20EE622	PE-2	Operational Amplifiers and Linear ICs	3-0-0	3	3
20EE623	PE-2	Fuzzy Logic Control	3-0-0	3	3
20EE624	PE-2	Renewable Energy Sources	3-0-0	3	3
20EE625	PE-2	Electrical Engineering Materials	3-0-0	3	3
Open Electives					
20OEEE61	OE-1	Basic Power Electronics	3-0-0	3	3
20OEEE62	OE-1	Alternate Energy Sources	3-0-0	3	3

Course Title	Linear Control Systems		
Course Code	20EE501	L-T-P	(3-1-0) 4
Exam	3 Hrs.	Hours/Week	4
SEE	50 Marks	Total Hours	52

Course Objective:
Students will learn to model and analyze control systems.

Course outcomes: At the end of course, student will be able to:

#	Course outcomes	Mapping to PO's	Mapping to PSO's
1	Demonstrate the skill to apply fundamental knowledge of modelling of electrical, mechanical and electro-mechanical systems.	1,2	1
2	Describe the basics on test signals, error constants and will be able to analyse time response specifications of second order systems.	1,2	1,2
3	Analyse the stability of a system using R-H criteria, root locus and frequency domain analysis	1,2,3	1,2
4	Describe P, PI, PD and PID Controllers and compensating networks	1,2	1,2

MODULE-1	13 Hrs

Modelling of Systems: Definition of control systems, open loop and closed loop systems, types of feedback, Differential equations of physical systems, analogous systems. Transfer function, transfer function for electrical, mechanical and electromechanical systems.
Block Diagrams and Signal Flow Graphs: Block diagram representation and reduction, Signal flow graph representation and reduction using Mason's gain formula

MODULE-2	13 Hrs

Time Domain Analysis: Standard test signals, Unit step response of first and second order systems. Time domain specifications and transient response of a second order system, steady state error and error constants.
Stability Analysis: Bounded input and bounded output stability, zero input and asymptotic stability, Methods of determining stability, Routh-Hurwitz criterion.

MODULE-3	13 Hrs

Root Locus Techniques: Root locus concepts, Rules for construction of root loci, Stability analysis.
Frequency Domain Analysis: Bode plots, Gain and phase cross over points, Frequency domain specifications. Resonant peak, resonant frequency and bandwidth

MODULE-4	13 Hrs

Polar plots, Nyquist stability criterion, Stability analysis.
P, PI, PD and PID Controllers. Introduction to compensating networks. Design of lag and lead compensators.

Text Book:
1. Nagrath and Gopal, Control System Engineering, New Age Internal, 4th Edition, 2005.

Reference Books:
10. K. Ogata, Modern Control Engineering, PHI/Pearson Education, 4th Edition, 2002.
11. B. C. Kuo, Automatic Control Systems, PHI, 7th Edition, 2002.
12. Smarajit Ghosh, Control Systems: Theory and Application, Pearson Education, 2004.

Course Title	Power Electronics		
Course Code	20EE502	L-T-P	(2-1-0) 3
Exam	3 Hrs.	Hours/Week	4
SEE	50 Marks	Total Hours	52

Course Objective: Students will be able to select a suitable power electronic switch and design a power electronic converter suitable for an application.

Course outcomes: At the end of course, student will be able to:

#	Course outcomes	Mapping to PO's	Mapping to PSO's
1	Explain the basic switching principle of various power electronic switching devices and their characteristics.	1	2
2	Analyze various techniques used to control the power electronic switching devices.	1	2
3	Describe working principle various power electronic converters for R & RL loads.	1,2	2
4	Solve numerical problems to design and analyse the performance parameters of various power electronic converters.	1,2,3	2

MODULE-1 — **13 Hrs.**

Introduction to Power Electronics, Power conditioning systems, Classification, ideal/practical switch characteristics, power semiconductor devices

Power Diode: Introduction, VI characteristics, Reverse Recovery Characteristics, types.

Power Transistors: Power BJTs – Structure, Switching Characteristics, Switching limits, Base-drive control circuits. Power MOSFETs (n channel enhancement type MOSFET) – Structure, Switching characteristics, Necessity of isolation, Isolation techniques, Gate drive requirements. IGBT- Structure, di/dt and dv/dt limitations.

Self study: Peripheral effects of Power electronic converters, Applications of Power electronic converters.

MODULE-2 — **13 Hrs.**

Thyristors: Characteristics, Two transistor model of Thyristor, Turn-on and turn-off, di/dt and dv/dt protection, Series and Parallel Operation of Thyristors, Thyristor firing circuits (RC firing, UJT firing, digital firing), Thyristor commutation techniques: Natural, Forced commutation (Load & Voltage commutation).

Controlled Rectifiers: Introduction principle & operation of phase-controlled converter, single-phase semi converter (RL load), single-phase full converter (RL load), single-phase dual converter (RL load), 3-phase half wave converters & 3-phase full converters (R load).

Self study: R firing of thyristors, TRIAC & DIAC characteristics, Controlled Rectifiers with R load.

MODULE-3 — **13 Hrs.**

AC Voltage Controllers: Introduction, Principle of ON-OFF control, Principle of phase control, single phase Bi-directional controller with resistive loads, Single phase controllers with inductive loads.

DC Choppers: Introduction, Classification of Choppers, Principle of step-down and step-up choppers, Step-down chopper with R-L load.

Self study: Analysis of step-down chopper with RL Load.

MODULE-4 — **13 Hrs.**

Inverters: Introduction, Principle of operation, Performance parameters, Single-phase bridge inverters, Three phase Inverters: 180-degree conduction, Voltage control of single-phase inverters: Sinusoidal pulse width modulation, delta modulation and stepped modulation, Voltage control of three phase inverters: Sinusoidal pulse width modulation and space vector modulation.

Self study: 120-degree conduction of three phase inverters.

Text Books: M.H. Rashid, Power Electronics, 3rd edition, Prentice Hall of India Pvt. Ltd., New Delhi, 2009.
Reference Books: 1. Dr. P.S. Bimbhra, Power Electronics, Khanna Publishers 1996. 2. M D Singh & Kanchandani, Power Electronics, TMH publishing company limited, Reprint 2001.

Course Title	**Engineering Electromagnetics**		
Course Code	**20EE503**	**L-T-P**	**(4-0-0)4**
Exam	**3 Hrs.**	**Hours/Week**	**4**
SEE	**50 Marks**	**Total Hours**	**52**

Course Objective: Students will learn to apply the knowledge of Electromagnetics in diverse areas of Engineering Electromagnetics.

#	Course Outcomes	Mapping to PO's	Mapping to PSO's
1	Explain the basics in the area of electric field, magnetic field and time varying electromagnetic field.	**1,2**	**2**
2	Explain fundamental laws governing electromagnetic fields.	**1,2**	**2**
3	Evaluate/Determine the physical quantities of electromagnetic fields (Field intensity, Flux density etc.) in different media using the fundamental laws. Evaluate/Determine the electromagnetic force exerted on charged particles, current elements, working principle of various electric and electromagnetic energy conversion devices are based on this force.	**1,2,3**	**2**
4	Solve or design energy storage devices like capacitor, inductor which are frequently used in electrical systems. Solve and analyze electric field intensity, potential difference, charge density, charge etc. for given boundary conditions using Laplace's /Poisson's equation. using boundary.	**1,2,3**	**2**

Course outcomes: At the end of course, student will be able to:

MODULE – 1	**14 Hrs.**
Introduction to co-ordinates, representation of vectors in different co-ordinates, Coulomb's Law, Electric field intensity, Electric field intensity calculations due to point charge, line charge surface charge. Electric flux density, Gauss's law, Examples on Gauss's law applications, Vector operator ∇ and Divergence theorem – Statement and proof.	

MODULE – 2	**14 Hrs.**
Work done in moving a point charge in an electric field and its line integral, Definition of potential difference and potential, Electric field as a negative gradient of potential. Current and current density, Equation of continuity, Metallic conductors, Properties of conductors, Properties of dielectrics, Boundary conditions for perfect dielectrics, Boundary conditions between conductor and dielectric.	

MODULE -3	**12 Hrs.**
Capacitance and examples, Poisson's and Laplace's equations, Uniqueness theorem and examples of Laplace's and Poisson's equations. Steady magnetic field, Biot-Savart's law, Ampere's circuit	

law, Curl, Stoke's theorem - statement, Magnetic flux and flux density, Scalar and vector magnetic potentials.

MODULE -4	12 Hrs.

Force on a moving charge – Lorentz force equation, Force on a differential current element and between differential current elements, Force and torque on a closed circuit. Classification and properties of magnetic materials, Self-inductance. Time-varying fields, Faraday's Law, Transformer and Motional e.m.f., Displacement current, Maxwell's equations in point and integral forms.

Text Books:

1. Matthew N.O. Sadiku, *Elements of Electromagnetics,* 3rd Edition, Oxford University Press, 2000.

Reference Books:

1. William H. Hayt Jr. and John A. Buck, *Engineering Electromagnetics*, 7th Edition, Tata McGraw-Hill, 2005.
2. D. Ganesh Rao and C. K. Narayanappa, *Engineering Electromagnetics – A simplified approach*, Revised Edition, Sanguine Technical publishers, 2004.

Course Title	**Power System Analysis & Stability**		
Course Code	**20EE504**	**L-T-P**	**(3-1-0) 4**
Exam	**3Hrs.**	**Hours/Week**	**4**
SEE	**50 Marks**	**Total Hours**	**52**

Course Objective: To apply classical methods for representation of Electrical Power systems for fault analysis and stability studies.

Course outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to PO's	Mapping to PSO's
1.	Define and explain technical terms as applied to Electrical Power system analysis.	1	1
2.	Solve various numerical examples for fault and stability analysis of given Electrical Power system.	1,2,3	1
3.	Model simplified equivalent circuits of a given power system.	1,2	1
4.	Analyze a given power system through its simplified model.	1,2,3	1

MODULE-1	13 Hrs.

Representation of Power System Components: Circuit models of transmission lines, Synchronous machines, Transformers & loads, one-line diagrams, impedance and reactance diagrams, per-unit systems, Change of base rule, merits and demerits, per unit impedance diagram of power system, illustrative examples.

Formation of Y_{BUS}: Frames of reference, Determining Y_{BUS} in bus frame of reference by the method of rule of inspection, Advantages of the method, Inferences drawn with respect to the % sparsity of Y_{bus}.

Symmetrical 3 Phase Faults: Transients on transmission lines, Short circuit currents and the time varying reactances of synchronous machines by considering the subtransient, transient and steady state periods

of short circuit, selection of circuit breakers based on various Short circuit studies , illustrative examples.	
MODULE-2	**13 Hrs.**
Symmetrical Components: Analysis of unbalanced loads against balanced 3-phase supply, resolution of unbalanced phasors into their symmetrical components and vice versa, phase shift of symmetrical components of currents and voltages in 3 ϕ, Y-Δ and Δ-Y connected transformer banks, power in terms of symmetrical components, consideration of power invariancy conditions, analysis of balanced and unbalanced loads against unbalanced 3ϕ supply, illustrative examples. **Sequence Impedances and Sequence Networks:** Positive, negative and zero sequence impedances, concept of neutral impedance, consideration of positive, negative and zero sequence diagrams with all kinds of power system elements involved such as, - Alternator, transformer, transmission line, etc., neutral line currents in zero sequence diagrams, obtaining the equivalent sequence diagrams at the point of fault, illustrative examples.	
MODULE-3	**13 Hrs.**
Unsymmetrical Faults: Line to Ground (LG) faults, Double Line (LL) faults, Double Line to ground (LLG) faults and 3 phase to ground (LLLG) faults on an unloaded alternator with-out and with the fault impedance Zf, consideration of c.u.f, d.c.u. f, connection of sequence networks, expression for various faulty parameters for all the above kinds of faults, illustrative examples. **Unsymmetrical Faults on Power System:** Consideration of all the types of unsymmetrical faults with reference to a general point of fault "F" of a power system with-out and with the fault impedance $Z_{f.}$, calculation of fault current at the point of fault with-out and with the fault impedance $Z_{f.}$ for the Power System faults. **Open conductor faults in power systems:** Single conductor open faults & two conductors open faults, Illustrative examples.	
MODULE-4	**13 Hrs**
Stability Studies: Steady state stability, Dynamic stability and Transient Stability, Definitions, stability margins, Bad effects of Instability, concept of Power Angle equation and Power Angle curves, Rotor dynamics and the Swing equation, derivation, Significance of Swing equation, Inertia constants M and H, Equation for kinetic energy and Inertia constants, illustrative examples. **Solution of Swing Equation:** Exposure to the various methods of solving the swing equation, step-by-step method- I and II, determination of the stability status of a system by the concept of equal area criterion of stability, illustrative examples.	

Text Books:

1. W.D. Stevenson, *Elements of Power System Analysis*, McGraw Hill, 2004.

Reference Books:

1. J. Nagrath and D. P. Kothari, *Modern Power System Analysis*, Third Edition, Tata McGraw Hill, 2003.

Course Title	Switch Gear Protection & Distribution		
Course Code	20EE505	L-T-P	(3-0-0) 3
Exam	3 Hrs.	Hours/Week	3
SEE	50 Marks	Total Hours	40

Course Objective: Students will be able to recognize and explain switch gear devices.

Course Outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to PO	Mapping to PSO's
1	Explain the basics in the field of power system protection, relays and circuit breaker.	1,2	1
2	Describe the features, working principle, and theories explaining the working of circuit breakers.	1,2	1
3	Explain the different protective methods to be employed in a needy situation.	1	1
4	Describe the different types of distributors and analyze them.	1,2	1

MODULE-1 — **10 Hrs.**

Switches and Fuses: Isolator, Earthing switches, Load breaking switch, fuse, types of fuse, fuse material, cut off characteristics of fuse, Discrimination, selection of fuse links for different types of load, HRC fuse.

Principles of Circuit Breakers: Functions of Circuit breakers, Current interruption in AC circuit breaker, transient Recovery voltage(TRV), factors affecting TRV, Restriking Voltage, RRRV, Recovery Voltage.

Self Study: Application of fuses.

MODULE-2 — **10 Hrs.**

Principles of Circuit Breakers: Initiation, maintenance and interruption of Arc, Arc Extinction modes, Arc interruption theories – Slepain's theory and Energy balance theory, Current chopping, Interruption of capacitive current, DC Circuit breaking, Making and breaking capacity of circuit breakers. **Circuit Breakers:** Rating of circuit breakers, classification of circuit breakers, Air- break circuit breakers, Airblast circuit breakers, Properties of SF_6, SF_6 circuit breakers, Indirect methods of testing circuit breakers.

Self Study: Vacuum circuit breakers.

MODULE-3 — **10 Hrs.**

Protective Relaying: Relay – Definition, faults causes and effects, Zones of protection, Primary and backup protection, Qualities of protective relaying, Specific terminologies of relevance, Classification of Relays, Plug setting (PS), Plug setting multiplier (PSM), Time multiplier setting (TMS) and relay Characteristics-DMT and IDMT characteristics. **Induction types relays**: Non-directional and directional Induction type over current relay, Impendence relay, Reactance Relay and Mho relay

Self Study: Distance Protection – Principle of operation.

MODULE-4 — **10 Hrs.**

Power Distribution Systems: Introduction, Radial and Ring main systems, D.C. Three-wire Systems, Different types of Distributors, Method of calculations, A.C. Distributors with concentrated loads-Numerical problems.

Self Study: D.C. Distributor with Distributed Load fed at both ends.

Text Books:

1. Sunil S Rao, Switchgear and Protection, Khanna Publishers, 1986.
2. A. Chakrabarti et. al., Power System Engineering.

Reference Books:

1. Badriram and D.N. Vishwakarma, Power System Protection and Switchgear, TMH, 2005.
2. B. Ravindranath and M. Chander, Power System Protection and Switchgear, New Age International Pvt. Limited, 1977.

Course Title	Digital Signal Processing		
Course Code	20EE506	L-T-P	(2-2-0) 3
Exam	3 Hrs.	Hours/Week	4
SEE	50 Marks	Total Hours	52

Course Objective: Students will be able transform digital signals and design digital filters.

Course Outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to PO	Mapping to PSO's
1	Transform signals using discrete Fourier and Fast Fourier transforms.	1,2,3	2
2	Realize IIR and FIR digital systems in various forms.	1,2,3	2
3	Design IIR filters as per required specifications.	1,2,3,4	2
4	Design FIR filters as per required specifications.	1,2,3,4	2

MODULE-1	10 Hrs.

Discrete Fourier Transforms: Definitions, Circular shift, Properties of DFTs, Circular convolution, Stockham's method, Linear convolution of two finite duration sequences, Filtering of long sequences.

MODULE-2	10 Hrs.

Fast Fourier transforms algorithms: Introduction, decimation in time algorithm, decimation in frequency algorithm, decomposition for 'N' a composite number, computation of DFTs and IDFTs. **Realization of digital systems:** Introduction, block diagrams, Realization of IIR systems-direct form, Cascade form, Parallel form.

MODULE-3	10 Hrs.

Realization of FIR systems: Introduction, Direct form, cascade form, linear phase realizations. **Design of IIR Digital filters:** Introduction, Types of filters, Analog Butterworth and Chebyshev filters, frequency transformations.

MODULE-4	10 Hrs.

Methods of Designing Digital Filters, Impulse Invariant and Bilinear Transformations, Design of digital Butterworth and Chebyshev filters, Frequency transformations. **Design of FIR Digital filters:** Introduction, Windowing, rectangular, Hamming windows, Frequency sampling technique.

Text Books:

1. John G. Proakis and Dimitris G. Manolakis, Digital Signal Processing: Principle, Algorithms and Applications, Fourth Edition, PHI, 2007.

Reference Books:

1. Johnny R. Johnson, Introduction to Digital Signal Processing, PHI, 2003.
2. B. Somanathan Nair, Digital Signal Processing, PHI. 2003.

Course Title	DC & Synchronous Machines Laboratory		
Course Code	20EE507	L-T-P	(0-0-1.5) 1.5
Exam	3 Hrs.	Hours/Week	3
SEE	50 Marks	Total Hours	39

Course Objective: Students will be able to conduct tests on DC and synchronous machines.
Course outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to POs	Mapping to PSO's
1	Demonstrate experimental skills to analyze the characteristics of DC and Synchronous machines.	1,2,9,10	1
2	Demonstrate experimental skills to test DC and Synchronous machines	1,2,9,10	1
3	Demonstrate fundamental control practices associated with DC machines (speed control, starting, reversing, braking, plugging etc.).	1,2,9,10	1

1. Open circuit characteristics of a D.C. Shunt Generator and determination of critical resistance
2. Load Characteristics of a D.C. Shunt Generator.
3. Load test on a DC shunt Motor – determination of speed-torque and BHP-efficiency characteristics
4. Speed control of DC shunt motor by Armature Voltage control and Flux control.
5. Swinburne's test
6. Hopkinton's Test
7. Retardation test on DC shunt motor.
8. Load test on DC compound generator.
9. Voltage Regulation of Alternator by EMF and MMF methods.
10. Voltage regulation of an alternator by zero power factor method.
11. Determination of X_d , X_q & regulation of a salient pole alternator : Slip rest
12. Performance of synchronous generator connected to infinite bus, constant power-variable excitation & vice versa
13. V and inverted V curves of a synchronous motor.

Course Title	Microcontroller Laboratory		
Course Code	**20EE508**	**L-T-P**	**(0-0-1.5) 1.5**
Exam	**3 Hrs.**	**Hours/Week**	**3**
SEE	**50 Marks**	**Total Hours**	**39**

Course Objective: Students will be able to program microcontrollers for various applications.
Course outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to POs	Mapping to PSO's
1	Demonstrate skills to write assembly level programs for a microcontroller to perform tasks such as block move, arithmetic operations, logical operations, subroutines.	1,2,3,5,10	2
2	Apply various programming techniques for developing the C program to perform tasks involving timers/counters, interrupts, time delays etc.	1,2,3,5,10	2
3	Demonstrate skills to interface LEDs, Push button, LCD, DAC, DC motor, stepper motor with 8051 and write C program for their operation.	1,2,3,5,10	2

Assembly Level Programming

1. Simple programs using mainly data transfer instructions: Block move, Exchange, Sorting, Finding largest element in an array.
2. Programs involving arithmetic operations like addition, subtraction, multiplication and division, square, cube of 8 bit data bytes.

3. Programs involving arithmetic operations like addition and subtraction of 16 bit data bytes.	
4. Programs involving looping, indexing and counting.	
5. Programs requiring logical operations like logical OR, AND, XOR, shift and rotate.	
6. Programs on software timers/counters and delay routines. (Eg. BCD or Hex up/down counting requiring monitor subroutines to display the result in the data/address field of display)	
7. Programs for code conversion (Eg. BCD to binary, binary to BCD etc.)	
Interfacing	
8. Interfacing LED and Push button switch to 8051	
9. Programming 8051 to use external hardware interrupts.	
10. Interfacing bidirectional DC motor to 8051.	
11. Interfacing stepper motor with 8051.	
12. Interfacing 8-bit DAC0808 with 8051.	
13. Interfacing 7 segment display to 8051.	
14. Interfacing 16x2 LCD display to 8051.	

Course Title	**Environmental Science**		
Course Code	**20ENV**	**L-T-P**	**(2-0-0) 0**
Exam	**3 Hrs.**	**Hours/Week**	**2**
SEE	**50 Marks**	**Total Hours**	**26**

Course Objective: Students will be able to act on environmental protection.

Course Outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to PO	Mapping to PSO's
1	Apply with understanding the dimension of the societal health, safety, legal and cultural issues as engineer to the given Engineering problem of environmental concern.	6,8	-
2	Evaluate the need for sustainable development having understood the adverse effects of present-day development on the environment and by Self-reflection on the individual day to day practices	7,12	-
3	Develop and present report effectively as member/ leader of the team on the optimal use resources at individual and group level using modern tools.	5,9,10	-
4	Demonstrate the adoption of ethics and lifelong practice of learning, the role and responsibility towards the environment as an engineering professional.	8,12	-

MODULE-1	**4 Hrs.**
Environment : Definition, Eco system – components of ecosystem, Balanced eco system. Impact of human activities on environment – Agriculture – Housing – Industry – Mining and Transportation.	
MODULE-2	**6 Hrs.**
Environmental Pollution: Water pollution-, Air pollution – Land pollution- Noise Pollution.	
MODULE-3	**8 Hrs.**
Global Environmental Issues : Water & Waste Water Management. Climate change and Global Warming, Acid rain & Ozone layer depletion: controlling measures. Land Management, Solid Waste Management, E – Waste Management & Biomedical Waste Management – Sources, Characteristics & Disposal methods, Population Growth, Urbanization,	

MODULE-4	8 Hrs.
Environmental Protection- Legal aspects: Environmental impact assessment and sustainable development. Environmental Acts & Regulations- Water act and Air act. Role of government and Nongovernmental Organizations (NGOs) , Environmental Education & Women Education.	

Text Books:

1. R Rajagopalan, "Environmental Studies – From Crisis to Cure", Oxford University Press, 2005
2. S.M. Prakash "Environmental Studies" Elite publishers, Mangalore. 2007

Reference Books:

1. Benny Joseph "Environmental Studies" Tata Mc Graw hill
2. P. Venugopala Rao "Principles of Environmental Science and Engineering" Prentice hall of India.
3. P. Meenakshi "Elements of Environmental Science and Engineering" Prentice hall of India Private Limited, New Delhi, 2006
4. Erach Bharucha, "Text Book of Environmental Studies", for UGC, University press, 2005

Course Title	**Analytical Ability Development**		
Course Code	**20AAD**	**L-T-P**	**(0-2-0) 1**
Exam	**3 Hrs.**	**Hours/Week**	**3**
SEE	**50 Marks**	**Total Hours**	**39**

Course Objective: Students will demonstrate analytical ability skills for solving problems.

Course Outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to PO	Mapping to PSO's
1	Apply analytical skills to solve problems	PO10	-

Speed, distance and time, Numbers, Clock and calendar, Permutations & combinations, Probability, Ratios and proportions, Profit & loss, Percentage, Simple & compound interest.

<u>Scheme of Evaluation:</u>

CIE- 5 quizzes each for 10 marks.

SEE- One examination for 50 Marks at the end.

Course Title	Modern Control Theory		
Course Code	20EE601	L-T-P	(3-1-0)4
Exam	3 Hrs.	Hours/Week	4
SEE	50 Marks	Total Hours	52

Course objective: Students will be able demonstrate skills to conduct state space analysis.

Course outcomes: The student will be able to

#	Course Outcomes	Mapping to POS	Mapping to PSO's
1	Explain the basics of state space representation of a system.	1	1
2	Represent a system in different types of state space models from its classical mathematical model and solve state space equations.	1,2,3	1,2
3	Test controllability and observability of a system and design control system for various engineering applications.	1,2	1,2
4	Analyze stability of linear and nonlinear systems.	1,2,3	1,2

MODULE-1 — **13 Hrs**

Introduction to State variable analysis: Limitations of classical control theory, Concept of state, State variables, state space model for physical systems – electrical, mechanical and electromechanical systems.

State Space Model: State model of linear systems from differential equations and transfer function, direct (CCF and OCF), series and parallel decomposition, transfer function matrix from state model.

MODULE-2 — **13 Hrs**

Canonical Models: Similarity transformation of state model, Invariant property, Diagonal canonical model; Jordan canonical model.

Time Domain Analysis in State Space: Solution of time invariant state equation, state transition matrix (STM) & its properties, computation of STM using Power series, Laplace transformation, Cayley-Hamilton method and Canonical transformation method.

MODULE-3 — **13 Hrs**

Controllability and Observability: Concept of controllability and observability, Criterion for controllability and observability - Kalman's test and Gilbert's method. Linear transformation of state model into CCF and OCF.

Pole placement Techniques: Stability improvements by State feedback, necessary and sufficient conditions for arbitrary pole placement, Design of state feedback controllers, Ackerman's formula, design of state observers- full order observer and reduced order observer.

MODULE-4 — **13 Hrs**

Stability Analysis: Concept of stability, Equilibrium points, Liapunov's stability definitions, Sign definiteness of scalar functions, Liapunov's function and second method of Liapunov, Liapunov's method for Linear time invariant systems.

Stability of Non-linear systems: Causes of non-linearity, characteristic features of nonlinear systems, Stability of nonlinear systems by the method of Liapunov, Krasovski's theorem, Variable gradient method.

Text Books:

1. K.P. Mohandas, *Modern Control Engineering*, Sanguine Technical publishers, 2006.

Reference Books:

1. M. Gopal, *Digital Control & State Variable Methods*, 2nd Ed, Tata McGraw Hill, 2003.

2. Katsuhiko Ogata, *Modern Control Engineering*, 4th Edition, Pearson Education.
3. Benjamin C Kuo, *Automatic Control Engineering,* Prentice Hall India, 2002.Scott L. Miller, Donald G. Childers: "Probability and Random Process with application to Signal Processing", Elsevier Academic Press, 2nd Edition, 2013.

Course Title	**Computer Methods in Power Systems**		
Course Code	**20EE602**	**L-T-P**	**(3-1-0)4**
Exam	**3 Hrs.**	**Hours/Week**	**5**
SEE	**50 Marks**	**Total Hours**	**52**

Course objective: To design generalized computer algorithms for computer aided Power System Analysis, involving networks under various frames of reference.

Course outcomes: The student will be able to

#	Course Outcomes	Mapping to POS	Mapping to PSO's
1	Explain various avenues of computer applications in Electrical Power system.	1	1
2	Develop computer aided algorithms for various power system problems that are based on contemporary and modern industry-based methods.	1,2,3	1
3	Apply mathematical equations to develop computer aided algorithms for various power system problems.	1,2, 3	1
4	Solve various numerical problems for given Electrical Power system using computer aided algorithms.	1,2,3	1

MODULE-1	**13 Hrs**

Network Topology and Network Matrices: **(a)** Introduction, Elementary graph theory, Basic definitions, Oriented graph, Tree, Co-tree, Basic cut sets, Basic loops, Rank of a matrix, Singular and nonsingular matrices, **(b)** Incidence matrices – Element-node, Bus incidence, Tree-branch path, Basic cut-set, Augmented cut-set, Basic loop and Augmented loop matrices, Relation between different matrices **(c)** Primitive network matrices, Impedance form and Admittance form, illustrative examples. **(d)** Formation of network matrices by singular transformations in bus, branch and loop frames of reference (Y_{BUS}, Y_{BR} and Z_{LOOP}), and Illustrative examples.

MODULE-2	**13 Hrs**

Formation of Network Matrices: (a) Formation of interconnected network matrices by non-singular transformations using augmented interconnected network matrices in both the branch and loop frames of reference and hence arriving at a procedure of formation of network matrices in bus, branch and loop frames of reference, Relations between the different matrices, illustrative examples. **(b) Node Elimination by Matrix Algebra:** Derivation of generalized algorithms for a given electric power system for node elimination by matrix manipulation of performance equations, node elimination by considering; (i) the eligible nodes simultaneously and (ii) one node at a time, Illustrative examples.**(c) Algorithms for formation of network matrices:** Introduction, Partial network, Performance equation, algorithms for formation of bus impedance matrix- Z_{BUS} by building algorithms, General cases of Addition of Branch, Addition of Link, Simple cases of modifications of bus impedance matrix for network changes; changing the impedance value of the network elements, removal of an element, etc., arriving at the simplified equations for the above with respect to electric power systems without any mutually coupled elements present (Y_{pqrs}=0), illustrative examples, very simple problems involving mutually coupled elements ($Y_{pqrs} \neq 0$).

MODULE-3	13 Hrs
Review of Solution of equations: Introduction, Methods of solving linear, Nonlinear and differential equations, iterative methods, Generalized algorithms for solution of linear equations by Gauss elimination and LU factorization methods, Algorithms for solution of nonlinear equations by Gauss-Siedel and Newton-Raphson methods, examples. **Load Flow Studies:** Introduction, Power flow equations, Classification of buses, Operating constraints, Data for load flow, importance of slack bus and Y_{BUS} in load flow analysis**,** Gauss-Siedel Method, algorithm and flow chart for PQ and PV buses, acceleration of convergence, illustrative examples (numerical problems for maximum of two iterations only).	
MODULE-4	13 Hrs
NR and FDLF Methods of Load Flow Studies:(a) Newton Raphson Method – Algorithm and flow chart for NR method in polar coordinates, importance of Jacobian matrix, Sparsity considerations, solution procedure for systems involving PQ and PV buses, illustrative examples (numerical problems for one iteration only). **Decoupled and: (b)** Newton's Decoupled method and its advantages, FDLF Analysis: Algorithm and flow chart for Fast Decoupled load flow method, assumptions made, Comparison of Load Flow Methods, **(c)** Representation of tap changing transformers on no-load and under load for load flow studies, examples.	
Text Books: 1. Stagg, GW, and EI-Abiad AH, *Computer Methods in Power System Analysis* McGraw Hill International Student Edition. 1988. 2. Pai, M. A., *Computer Techniques in Power System Analysis*, TMH, 2nd Edition, 2006. 3. K. Uma Rao, *Computer Modeling of Power Systems,* Interline publ., Bangalore, 2008.	

Course Title	Electrical Machine Design		
Course Code	20EE603	L-T-P	(3-1-0) 4
Exam	3 Hrs.	Hours/Week	4
SEE	50 Marks	Total Hours	52

Course Objective: Students will be able to design electrical machines.

Course Outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to PO	Mapping to PSO's
1	Demonstrate strong analytical foundation for understanding all types of Electrical machines.	1	1
2	Use basic mathematical relations in electric circuits, magnetic circuits and dielectric circuit for the design of electrical machines.	1,2,3	1
3	Demonstrate sound knowledge about constructional details and design of various electrical machines.	1	1
4	Demonstrate the skill to use IS standards and DDH for the design of machines.	1	1
5	Design a machine for the specified application.	1,2,3	1

MODULE-1	12 Hrs
Basic principles of electrical machine design: Introduction, Considerations for the design of electrical machines, limitations. Different types of materials and insulators used in electrical machines. **Design of transformers (Single phase and three phase):** Brief discussion on construction; Output equation for single phase and three phase transformers, Choice of specific loadings, Expression for	

volts/turn, determination of main dimensions of the core, Estimation of number of turns and cross-sectional area of Primary and secondary coil. **Self Study:** Design for maximum efficiency, Design for optimum output	
MODULE-2	**13 Hrs**
Different types of windings, General arrangement of windings. Design of LV and HV windings, Estimation of losses and no load current, Design of the tank and cooling tubes. **Design of Induction motors:** Brief discussion on construction, Output equation, choice of specific loadings, main dimensions of three phase induction motor, stator winding design, choice of length of the air gap, estimation of number of slots for the squirrel cage rotor, estimation of dimension of the slot **Self Study:** Study of different types of prime movers.	
MODULE-3	**14 Hrs**
Rotor design, Length of the air gap, Types of rotor, Design of squirrel cage rotor, design of Rotor bars and end ring, design of wound rotor, Estimation of no load current of Induction motor. **Design of synchronous machines:** Brief discussion on construction, Output equation, choice of specific loadings, short circuit ratio, number of slots for the stator, Design of main dimensions, armature winding, slot details for the stator of salient synchronous machine. **Self Study:** Study of different types of prime movers.	
MODULE-4	**13 Hrs**
Design of rotor of salient pole synchronous machine, Dimensions of the pole body, Estimation of height, number of turns and arrangement of turns for the field winding. Design of main dimensions, armature winding, slot details for the stator of non-salient pole synchronous machine, Design of rotor and field system of non-salient pole machine. **Self Study:** Ampere turns calculation for different parts of the machine.	

Text books:

1. A.K. Sawhney, A *Course in Electrical Machine Design*, 6th Edition, Dhanpat Rai & Sons, 2006.

Reference Book:

1. V.N.Mittle, *Design of Electrical Machines*, 4th Edition, Standard Publishers, 1996.
2. Sahnmugsundaran & Palani: *Electrical Machine Design Data Hand Book* New Age International, 2004.

Course Title	**Power Electronics Laboratory**		
Course Code	**20EE604**	**L-T-P**	**(0-0-3) 1.5**
Exam	**3 Hrs.**	**Hours/Week**	**3**
SEE	**50 Marks**	**Total Hours**	**39**

Course Objective: Students will be able to demonstrate skills to examine various power electronic circuits

Course outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to POs	Mapping to PSO's
1	Demonstrate experimental skill to determine the switching characteristics of Power Electronic devices.	1,2,9,10	2
2	Examine various gate/base drive circuits to drive power electronic devices.	1,2,9,10	2

3	Analyze various power electronic converters to drive R and RL loads.	1,2,5,9,10	2

1. Static characteristics of *SCR.*
2. Static characteristics of *TRIAC*.
3. Static characteristics of *MOSFET.*
4. Static characteristics of *IGBT*.
5. Controlled HWR and FWR using RC Triggering circuit for resistive Load.
6. Controlled Half wave rectifier using synchronized UJT firing circuit for resistive load.
7. Generation of Firing signals for Thyristors using digital firing circuit.
8. AC voltage controller using TRIAC-DIAC combination for resistive & R-L Load.
9. Voltage (Impulse) commutated chopper – both constant frequency and variable frequency operations.
10. Speed control of universal motor / single phase induction motor.
11. Control of stepper motor in half step and full step mode.
12. Simulation of Single phase and Three phase Inverters.

Course Title	**Control Systems Laboratory**		
Course Code	**20EE605**	**L-T-P**	**(0-0-3) 1.5**
Exam	**3 Hrs.**	**Hours/Week**	**3**
SEE	**50 Marks**	**Total Hours**	**39**

Course Objective: Students will be able to demonstrate skills to analyse the operation and stability of analog and digital control systems.

Course outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to POs	Mapping to PSO's
1	Explain the operation of basic control system equipments by conducting suitable experiments on them.	1,9,10	2
2	Design suitable compensators for given specifications.	1,2,3,9,10	2
3	Analyze the characteristics of a given system by conducting suitable experiments on it.	1,2,3,5,9,10	2
4	Using MATLAB, analyse and interpret stability of the system through Root Locus, Bode plot and Nyquist plot.	1,2,3,5,9,10	2

To study the performance characteristics of a synchro-pair.

To determine the step response of a second-order system and evaluation of time domain specifications.

To study the effect of P, PI and PD controller on the step response of a feedback control system.

(i) To design a passive RC lag compensating network for the given specifications., viz., the maximum phase lag and the frequency at which it occurs, and to obtain its frequency response.
(ii) To determine experimentally the transfer function of the lag compensating network.

(i) To design a passive RC lead compensating network for the given specifications, viz., the maximum phase lead and the frequency at which it occurs and to obtain its frequency response.
(ii) To determine experimentally the transfer function of the lead compensating network.

Experiment to draw the frequency response characteristic of a given lag-lead compensating network.

To determine the frequency response of a second-order system and evaluation of frequency domain specifications.

(i) Simulation of a typical second order system and determination of step response and evaluation of time-domain specifications using MATLAB. (ii) Analyze the effect of the variation of damping ratio in a typical second order system using MATLAB.
MATLAB simulation of root loci of a given transfer function and analysis of the stability of the system.
MATLAB simulation of Bode plot of a given transfer function and analysis of the stability of the system.
MATLAB simulation of Nyquist plot of a given transfer function and analysis of the stability of the system.

Elective – Group I

Course Title	**Testing & Commissioning of Electrical Equipments**		
Course Code	**20EE611**	**L-T-P**	**(3-0-0) 3**
Exam	**3 Hrs.**	**Hours/Week**	**3**
SEE	**50 Marks**	**Total Hours**	**40**

Course Objective: Student will be able to demonstrate testing and commissioning various electrical equipments.

Course Outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to PO	Mapping to PSO's
1	Plan, control and implement commissioning of electrical equipment.	1,6	1
2	Demonstrate the knowledge of need and method for testing of each part of equipment to prove the reliability.	1,6	1
3	Perform corrective and preventive maintenance of electrical equipment.	1,6	1

MODULE-1	10 Hrs

Transformers: Specifications: Power and distribution transformers as per BIS Standards. Installation: Location, Site, Selection, foundation details, Code of practice for rating and terminal plates, Oil tanks and their testing, drying of transformers.

Testing of Transformers: Tests as per national & International Standards, polarity testing, measurement of winding resistance, volt ratio test, measurement of insulation resistance and polarization index, short circuit test, dielectric test, temperature rise test, impulse testing.

Self Study: Polarity and phase sequence in Transformers.

MODULE-2	10 Hrs

Testing of Transformers: Partial discharge test, power frequency withstand test, sudden short circuit withstand test, induced over voltage withstand test, efficiency and regulation, tap changer, Transformer accessories, fitments and safety devices, over fluxing failure, commissioning of transformers.

Switchgear and protective devices: Introduction, circuit breaker, types, specifications, tests on circuit breakers, installation, possible trouble, causes and corrective actions for outdoor circuit breakers, maintenance of circuit breakers, HVDC circuit breaker, fuses and specifications, metal clad switch gear, contactor.

Self Study: Causes of troubles and failures in power transformers and switchgear devices and preventive actions.

MODULE-3	10 Hrs

Induction Motors: Specifications: Introduction, rating plate, duty, type 'n' protection, installation, drying of windings, Testing of induction motors: Mechanical tests: alignment & air gap symmetry,

bearings, vibrations, balancing), Electrical Electrical tests: Insulation test, high voltage test, load test, no load test, locked rotor test, temperature rise test, power factor measurement, starting test, determination of slip, efficiency, speed torque, shaft current and voltages, running up test, effect of variation of supply frequency, methods of starting, installation. **Self Study:** Troubles causes and remedies and protection of induction motor.

MODULE-4	10 Hrs
Synchronous Machines: Introduction, specifications, installation, procedure to start alternators, excitation system, cooling, types of enclosure, drying of windings, Testing: types of tests, measurement of insulation resistance, dc resistance, open circuit test, sustained three phase short circuit test, short circuit ratio, sudden three phase test, negative phase sequence test, slip test, power frequency voltage withstand test, over speed test, vibration test, temperature rise test, double line to neutral sustained short circuit test, line to line sustained SC test. **Self Study:** Abnormal conditions and protection of generators.	

Text books:

1. S. Rao, Testing & Commissioning of Electrical Equipment, Khanna publishers, 1984.
2. Ramesh L. Chakrasali, Testing and Commissioning of Electrical Equipment, Prism Books Pvt. Ltd., 2014.

Reference Books:

1. B.V.S. Rao, *Testing & Commission of Electrical Equipment*, Relevant Bureau of Indian Standards.
2. J & P Transformer Handbook.
3. J & P Switchgear Hand Book.

Course Title	Special Electrical Machines		
Course Code	**20EE612**	**L-T-P**	**(3-0-0) 3**
Exam	**3 Hrs.**	**Hours/Week**	**3**
SEE	**50 Marks**	**Total Hours**	**40**

Course Objective: Students will be able to assess the performance of modern electrical machines
Course Outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to PO	Mapping to PSO's
1	Explain the working principle of Stepper motor, SRM, PMDC, SyRM, Single phase, servo, linear electric motors	1	1
2	Analyze various characteristics of special electrical machines.	1,2	1
3	Analyze the control of special electrical machines.	1,2	1
4	Select suitable special electrical machine for a particular application.	1	1

MODULE-1	10 Hrs
Stepper Motor: Introduction, Variable Reluctance Stepper Motor, Permanent Magnet Stepper Motor, Hybrid Stepper Motor, Other Types of Stepper Motor, Windings in Stepper Motors, Torque Equation, Characteristics of Stepper Motor, Open – loop Control of Stepper Motor, Closed – loop Control of Stepper Motor, Microprocessor – Based Control of Stepper Motor, Applications of Stepper Motor.	

MODULE-2	10 Hrs
Switched Reluctance Motor (SRM): Construction, Principle of Working, Basics of SRM Analysis, Constraints on Pole Arc and Tooth Arc, Torque Equation and Characteristics, Power Converter Circuits,	

Control of SRM, Rotor Position Sensors, Current Regulators, Microprocessor – Based Control of SRM, Sensorless Control of SRM.
Permanent Magnet DC Motor and Brushless Permanent Magnet DC Motor: Permanent Magnet DC (PMDC) motor, Brushless Permanent Magnet DC (BLDC) Motors

MODULE-3	**10 Hrs**

Permanent Magnet Synchronous Motor (PMSM): Construction, Principle of Operation, EMF Equation, Torque Equation, Phasor Diagram, Circle Diagram, Comparison of Conventional and PMSM, Control of PMSM, Applications.
Synchronous Reluctance Motor (SyRM): Constructional of SyRM, Working, Phasor Diagram and Torque Equation, Control of SyRM, Advantages and Applications

MODULE-4	**10 Hrs**

Single Phase Special Electrical Machines: AC series Motor, Repulsion Motor, Hysteresis Motor, Single Phase Reluctance Motor, Universal Motor.
Servo Motors: DC Servo Motors, AC Servo Motors
Linear Electric Machines: Linear Induction Motor, Linear Synchronous Motor, DC Linear Motor, Linear Reluctance Motor, Linear Levitation Machines.

Text books:

1. Janardhan E.G. *Special Electrical Machines*, PH.
2. K Venkataratnam, *Special Electrical Machines*, CRC press

Reference Books:

1. Danne & Hanselman, *Brush Less Permanent Magnet Motors*, Mc Graw Hill.
2. A.Landsdorf, *Alternating Current Machinery*, TMH.

Course Title	**Electronic Instrumentation Techniques**		
Course Code	**20EE613**	**L-T-P**	**(3-0-0) 3**
Exam	**3 Hrs.**	**Hours/Week**	**3**
SEE	**50 Marks**	**Total Hours**	**40**

Course Objective: Students will be able to explain the techniques for electronic measurement and instrumentation.
Course Outcomes: At the end of course, student will be able to:

#	**Course Outcomes**	**Mapping to PO**	**Mapping to PSO's**
1	Explain the basics of the electrical and electronic instruments and equipment.	1	2
2	Design of various electronic equipment and can operate them in the laboratories and industries.	1,2	2
3	Take the readings from the different charts, plotters, meters and recorders.	1	2
4	Explain complete information about the various application domains of measuring instruments.	1	2

MODULE-1	**10 Hrs**

Digital display system and indicators, classification, display devices, LEDs, LCDs, Gas Discharge Plasma Displays, Segmented Gas Discharge Displays, Segmented Displays using LEDs, Dot Matrix Displays. Transistor voltmeter, micro voltmeter, solid state voltmeter, differential voltmeter, rectifier voltmeters, RMS voltmeters, RMS meter, Ohm meter, multimeter.

MODULE-2	10 Hrs
Digital voltmeter, dual slope integrating type and integrating type DVM, Successive Approximation type DVM, Fixed frequency AF oscillator, variable AFO, standard signal generator, AF sine and square wave generator. Function generator, square and pulse generator Output power meters, field strength meter, stroboscope phase meter, direct reading impedance meter, Q meter.	
MODULE-3	**10 Hrs**
LCR bridge RX meters, automatic bridges, transistor tester, megger, Strip chart recorder, galvanometer type, null type circulars, and bridge type recorders. Linear servo motor recorder,chart recorder, x-y recorder, digital x-y plotters, magnetic recorders, Frequency modulation recording, Digital data recording.	
MODULE-4	**10 Hrs**
Electrical transducer, selecting a transducer, resistive transducer, resistance pressure transducer, resistive position transducer, strain gauges, bonded and unbonded resistance wire strain gauge. Types of strain gauges, Resistance Thermometer, thermistor, inductive transducer, differential output transducer, LVDT, pressure inductive transducer, capacitive transducer.	

Text books:

1. H.S. Kalsi, *Electronic Instrumentation*, Tata McGraw-Hill, 1995

Reference Books:

1. Albert D.Helfrick, William D. Cooper, *Electronic Instrumentation & Measurement Techniques*, PHI, 1990.
2. A.K. Sawhney, *Electrical & Electronic Measurements and Instrumentation*, Dhanpat Rai & sons, 1973.

Course Title	Smart Grid Technologies		
Course Code	**20EE614**	**L-T-P**	**(3-0-0) 3**
Exam	**3 Hrs.**	**Hours/Week**	**3**
SEE	**50 Marks**	**Total Hours**	**40**

Course Objective: Students will be able to demonstrate the practical insight about the modernization of Electrical Power System and solve several issues involved in realization of Smart Grid.

Course Outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to PO	Mapping to PSO's
1	Interpret different components of smart grid	1	1
2	Identify various avenues of Smart grid in context to real time power system operations.	1	1
3	Explain and analyse operational features of Smart grid.	1	1
4	Assess role of Smart grid to address real life challenges in power system operation and control	1,6	1

MODULE-1	10 Hrs
Introduction to Smart Grid: Evolution of Electric Grid, Evolution of Indian National Grid, Regulatory authorities in Indian Power sector, Concept of Smart Grid, Why implement the Smart Grid now? Early Smart Grid initiatives, Overview of the technologies required for the Smart Grid, Opportunities & Barriers	

of Smart Grid, Difference between conventional & smart grid. *INFORMATION AND COMMUNICATION TECHNOLOGIES:* Data communication- Introduction, switching techniques and communication channels. Layered architecture and protocols-ISO/OSI model and TCP/IP **Self Study:** Smart grid initiatives in India	
MODULE-2	**10 Hrs**
Sensing, Measurement, Control and Automation Technologies: Smart metering: Key components of smart metering, overview of the hardware used, Signal acquisition, Signal conditioning, Analogue to digital conversion, Computation, Input/output, Communication. *Communications infrastructure and protocols for smart metering:* Home-area network, Neighborhood area network, Data concentrator, Meter data management system, Protocols for communications, Demand-side integration, Services provided by DSI, Implementations of DSI, Hardware support to DSI implementations. **Self Study:** Cyber Security for Smart Grid	
MODULE-3	**10 Hrs**
Distribution Management System: Data sources and associated external systems-structure and main components, modeling and analysis tools, Applications. Power electronics in Smart Grid Introduction - current source converters, voltage source converters-VSC for low, medium and high-power applications. **Self Study:** Computational tools to Smart Grid	
MODULE-4	**10 Hrs**
Role of FACTS in Smart grid: Introduction, various compensation techniques. HVDC- CSC, VSC and multi terminal HVDC. *Energy storage*- introduction, various energy storage technologies. Case study- Agent based control of EV battery charging. **Self Study:** Microgrid and renewable energy.	
Text books: 1. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, "*Smart Grid: Technology and Applications*", wiley India.	
Reference Books: 3. Bharat Modi, Anu prakash and Yogesh Kumar "Fundamentals of Smart Grid Technology" 4. James Momoh "*SMART GRID Fundamentals of Design and Analysis*", IEEE press, A John Wiley & Sons, Inc., Publication	

Course Title	**Programmable Logic Controllers**		
Course Code	**20EE615**	**L-T-P**	**(2-0-1) 3**
Exam	**3 Hrs.**	**Hours/Week**	**4**
SEE	**50 Marks**	**Total Hours**	**52**

Course Objective: Students will be able to program PLCs for specific applications.

Course Outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to PO	Mapping to PSO's
1	Describe architecture and hardware of PLC.	1,5	2
2	Discuss input, output devices and memory management.	1,5	2
3	Apply ladder programming using basic control elements to solve control problems.	1,2,3,5	2

MODULE-1	**6 Hrs**

Introduction to PLC: Programmable logic controller hardware and internal architecture, CPU, buses, memory, input/output unit, sourcing & sinking, PLC programming.
Input devices: mechanical switches, proximity switches, photoelectric sensors and switches, encoders, temperature sensors.
Self Study: Interface of encoder device to PLC.

MODULE-2	6 Hrs

Input devices: Position sensors, strain gauges, pressure sensors, liquid level detectors, fluid flow sensors, solenoids, capacitive sensors, inductive sensors, ultrasonic, hall effect, smart sensors.
Output devices: Relay, solenoids, valves, single and double acting cylinders, motors, hydraulics, pneumatics.
Self Study: Stepper motors.

MODULE-3	7 Hrs

PLC Ladder programming: Ladder diagrams, PLC ladder programming, Logic functions, latching, multiple outputs, entering programs, Ladder programmes for simple applications.
Advanced Ladder Logic: Jump, jumps within jumps, subroutines, function boxes.
Self Study: Basics of IL, SFC and ST programming methods.

MODULE-4	7 Hrs

Advanced Ladder Logic: Types of timers, on-delay timer, off-delay timers, pulse timers, retentive timers, forms of counters, counter programming, up and down counting, sequencer.
Self Study: Timers with counters

Practical Component: **26 Hrs**

Ladder logic Programming of PLC:
1. AND, OR, NOT gates.
2. Staircase two way switch.
3. Sequencing.
4. Interlocking.
5. Master switch.
6. Toggle lights using Timer flipflop.
7. Product counting.
8. Traffic light.
9. Star delta starter.
10. Real time clock.

Text books:

1. W. Bolton, **"Programmable Logic Controllers"**, Elsevier Publication, Oxford UK.

Reference Books:

1. E.A Paar, ***"Programmable Controllers-An Engineers Guide"***, Newness publication.
2. Johnson Curties, ***"Process Control Instrumentation Technology"***, 8th edition, Prentice Hall of India.
3. John W Webb, Ronald Reis, ***"Programmable logic controller: principle and application"***, Pearson publication.

Elective – Group II

Course Title	**Object Oriented Programming with C++**		
Course Code	**20EE621**	**L-T-P**	**(3-0-0) 3**
Exam	**3 Hrs.**	**Hours/Week**	**3**
SEE	**50 Marks**	**Total Hours**	**40**

Course Objective: Students will be able to code a given problem using C++.

Course Outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to PO	Mapping to PSO's
1	Explain the basics of C++ programming, POP, OOP.	1,5	-
2	Explain the concepts of functions such as function overloading, generic functions etc. Explain the concepts Object Oriented Programming such as class, object, friend function, operator overloading, inheritance, virtual function, virtual class etc.	1,5	-
3	Apply and analyze the concept of functions using C++ to write programs.	1,2,3,5	-
4	Apply and analyze the concept of object oriented programming to write programs.	1,2,3,5	-

MODULE-1	**10 Hrs**

Introduction: Comparison between POP and OOP, Basic features and concept of OOP. The C++ Program, input operator, output operator, Pre-processor directives; The C++ Data Types: Basic data types, User defined data types. **Functions**: Function prototype, argument passing, returning a value, recursion, inline functions, lifetime - scope, global objects and functions, local objects.

MODULE-2	**10 Hrs**

Overloaded functions: overloaded function declarations, the three steps of overload resolution; Generic functions (function template), generic function restrictions, a generic sort. **Classes and Objects:** Introducing C++ classes: Classes, friend functions, friend classes, inline functions within a class, Constructors and destructors, static class members - static data members, static member functions.

MODULE-3	**10 Hrs**

The scope resolution operator; local classes, creating a member operator function: operator overloading and restrictions, Operator overloading using a friend function, examples involving unary and binary operators. **Inheritance:** Base class access control, inheritance and protected members, protected base class inheritance, inheriting multiple base classes, constructors, destructors and inheritance.

MODULE-4	**10 Hrs**

Virtual classes and functions: Virtual base classes, calling a virtual function through a base class reference, the virtual attribute is inherited, virtual functions, hierarchical, pure virtual functions. **The I/O stream library**: Handling Input and Output streams, File handling, Input-Output manipulators, Overloading the output operator «, Overloading the input operator ».

Text books:

1. Robert Lafore, *Object-Oriented Programming in C++*. The Waite Group, Galgotia Publications, Third Edition, 1999.

Reference Books:

1. Herbert Schmidt, *C++, The complete reference*, TMH, Third Edition, 1998.
2. John R Hubbard, *Programming with C++*, Schaum's Outline Series, McGraw Hill, Second Edition, 2000.

Course Title	Operational Amplifiers and Linear ICs		
Course Code	20EE622	L-T-P	(3-0-0) 3
Exam	3 Hrs.	Hours/Week	3
SEE	50 Marks	Total Hours	40

Course Objective: Students will be able to use Operational amplifiers (Op-amp) as building blocks to theoretically design op-amp based electronic circuits and systems.

Course Outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to PO	Mapping to PSO's
1	Explain the basics of Op-amps, ICs and Op-amp based AC amplifier circuit configurations.	1	2
2	Discuss the features, classification and working principle of Op-amp based circuits.	1	2
3	Demonstrate knowledge to use the 'Data sheets' and 'List of standard Resistors and Capacitors', for practical Op-amp based circuit implementation.	1,2	2
4	Demonstrate skill to design typical Op-amp based Linear & Non-linear circuits.	1,2,3	2

MODULE-1 — **10 Hrs**

Op-amps as AC Amplifiers: Capacitor coupled voltage follower, High Z_{in} capacitor coupled voltage follower, Capacitor coupled non-inverting amplifier, High Z_{in} capacitor coupled non–inverting amplifier, Capacitor coupled inverting amplifier, setting upper cutoff frequency, Use of single polarity supply.
Self Study: Fundamentals of Op-amps and ICs

MODULE-2 — **10 Hrs**

Signal Processing circuits: Precision half-wave and full-wave rectifiers, Limiting circuits, Clamping circuits, Peak detectors, Sample-and-Hold (S/H) circuit.
Self Study: Simulation of a Limiting circuit.

MODULE-3 — **10 Hrs**

Op-amps and Non-linear circuits: Op-amps in switching circuits, Crossing detectors, Inverting Schmitt trigger circuits. Non-inverting Schmitt circuits, Astable multivibrator, Monostable multivibrator.
Self Study Study: Simulation of a Schmitt trigger circuit.

MODULE-4 — **10 Hrs**

Signal generator: Triangular/Rectangular wave generator without frequency and duty cycle adjustment, Phase shift oscillator, Wein bridge oscillator.

Active filters: First and Second order Low-pass and High-pass filters; First order Band pass filter and First order Band stop filter.

Self Study: Simulation of an Oscillator or an Active filter.

Note: Students are permitted to use op-amp data sheets and standard Resistor and capacitor values list, for solving the design connected numerical problems in the examination. The said information is available in the Appendix of Text authored by David A. Bell.

Text books:

1. David A. Bell, Operation Amplifiers and Linear ICs, Prentice Hall of India, 2nd Edition, 2008.

Reference Books:

1. Ramakanth A. Gayakwad, Op-Amps and Linear Integrated Circuits, 4th Edition, Pearson Education, 2007.
2. R. Coughlin & F. Driscoll, Operational amplifiers and Linear Integrated Circuits, Prentice Hall of India, 6th Edition, 2004.

Course Title	Fuzzy Logic Control		
Course Code	20EE623	L-T-P	(3-0-0) 3
Exam	3 Hrs.	Hours/Week	3
SEE	50 Marks	Total Hours	40

Course Objective: Students will be able to program PLCs for specific applications.

Course Outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to PO	Mapping to PSO's
1	Explain the concept of fuzziness involved in various systems and gain adequate knowledge about fuzzy set theory.	1	2
2	Represent the problems in fuzzy membership functions.	1	2
3	Demonstrate ability to represent the any complex, non-linear real world problem fuzzy system.	1,2	2
4	Write fuzzy rules for various open and closed loop systems and Design Fuzzy based controllers for various applications	1,2,3	2

MODULE-1 — **10 Hrs**

Set Theory: Introduction to fuzzy theory, classical set, operation of classical sets**,** Fuzzy sets, operations on fuzzy sets, Properties of fuzzy sets, mapping of classical sets and fuzzy sets, notation of fuzzy set.
Relations: Crisp relation, Cartesian product, relation matrix for crisp relation, operations of crisp relation, fuzzy relations, operations of fuzzy relations, properties of fuzzy relations, fuzzy Cartesian product, composition.

MODULE-2 — **10 Hrs**

Continuous Membership function: Membership function**,** Types of membership functions, Plot of membership functions, Mathematical expressions for degree of membership, support, width, nucleus, height, core of a fuzzy, convex and non-convex fuzzy, normal and subnormal fuzzy.
Fuzzy Logic: Fuzzy proposition, fuzzy logic, operations of fuzzy logic, modus ponens, modus tollen inferences, compositional rule of inference, classical implication (Zadeh's implication), Mamdani's implication, approximate reasoning, fuzzy if then statements.

MODULE-3 — **10 Hrs**

Fuzzy systems: Linguistic variables, Linguistic hedges: fuzzy concentration, dilation and intensification, Rule based systems, Graphical techniques of inference: Mamdani's inference.
Fuzzification and Defuzzification: Concept of fuzzification, Defuzzification Methods : Maximum membership principle, Centroid method, Weighted average method, Mean max membership, Center of sums, Center of largest area, first (or last) of maxima.

MODULE-4 — **10 Hrs**

Fuzzy Knowledge Based Controllers (FKBC): Basic concept of fuzzy logic control, structure of FKBC, choice of membership functions, scaling factors, rules: value assignment for input and output variables, control rule table (FAM).
Applications: Fuzzy washing machine, Fuzzy traffic regulations, Fuzzy logic control of drives, P, PI and PID like FKBC.

Text books:

1. D. Driankov, H. Hellendoom and M. Reinfrank, *An Introduction to Fuzzy Control*, Narosa Publishers India, 1996.
2. Timoty Ross, *Fuzzy Logic with Engineering Applications*, McGraw Hill, 2009.

Reference Books:

1. R. R. Yaser and D. P. Filer, *Essentials of Fuzzy Modeling and Control*, John Wiley, 1994.
2. G. J. Klir and T. A. Folger, *Fuzzy Sets Uncertainty and Information*, PHI IEEE, 1995.

Course Title	Renewable Energy Sources		
Course Code	20EE624	L-T-P	(3-0-0) 3
Exam	3 Hrs.	Hours/Week	3
SEE	50 Marks	Total Hours	40

Course Objective: Students will analyse and design the renewable energy conversion system components for real time application.

Course Outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to PO	Mapping to PSO's
1	Discuss the basic knowledge about the importance of renewable energy sources & solar radiation measurements.	1,6,7	1
2	Design & cost estimation of solar thermal systems- solar collectors, solar water heater, solar cooker for domestic applications.	1,2,6,7	1
3	Analyse the performance of wind energy system components and wind speed assessment for different locations.	1,2,6,7	1
4	Analyse and design of tidal energy system and different types of biogas digesters	1,2,6,7	1

MODULE-1 **10 Hrs**

Energy Sources: Importance of energy sources, Classification of energy resources, comparison of conventional & non-conventional energy resources, disadvantages of non-conventional energy sources, renewable energy resources-classifications, advantages, obstacles to implementation of renewable energy sources.

Solar Energy Basics: Solar constant, solar radiation at the earth surface, Basic sun-Earth angles-definitions & their representation, Solar radiation geometry- Numerical problems, solar radiation measurements – Pyranometer & Pyrheliometer, Estimation of solar radiation of horizontal & tilted surfaces- numerical Problems.

MODULE-2 **10 Hrs**

Solar Thermal Systems and applications: Focusing and non- focusing type solar collectors and examples, Liquid Flat plate collectors –working principle, Performance analysis, Energy gain and thermal efficiency, numerical examples. Applications: Solar water heater, Solar driers, box type solar cookers, space heating, solar furnaces, solar green houses.

Solar thermal electric power generation: Low temperature STECS-Solar pond, Flat plate collector, medium temperature STECS –Parabolic cylindrical concentrator, high temperature STECS –paraboloidal dish type, central receiver system, solar photovoltaic-working principles, I-V and P-V characteristics.

MODULE-3 **10 Hrs**

Wind Energy: Wind flow-motion of wind, vertical wind variation, and distribution of wind speeds, wind speed characteristics, basic components of a wind energy conversion system (Block diagram of WECS), typical wind turbine for power generation, classification of WEC systems, Advantages and disadvantages of WECS, site selection consideration.

Power in the wind- concept of power co-efficient, maximum power obtained from the wind, torque and axial thrust of the wind turbine, numerical problems, tip speed ratio and solidity, annual energy production-approximate and accurate, estimation of required wind turbine power rating, wind Energy collectors-horizontal and vertical axis machines.

MODULE-4 **10 Hrs**

Biomass Energy: Introduction, types of biomasses and their applications, energy content of biomass. Photosynthesis process, Biomass conversion technologies, Biomass based fuels-production of charcoal production, formation of producer gas (gasification), biogas production, production of ethanol and methanol. Factors Affecting Biogas generation, types of Biogas plants – KVIC & Janata Model, design of a community biogas plant for a village.

Energy From Ocean: Ocean thermal energy- methods of ocean thermal electric power generation- open cycle (Claude cycle), Closed cycle (Anderson cycle). Energy from tides; basic principles of tidal power, components of tidal power plant (TPP), single basin arrangement- types of single basin systems, estimation of energy and power in single basin tidal system, simple problem, double basin arrangement-working principle only.

Text books:

1. Rai, G D, Non-conventional sources of energy, 4th Edition, Khanna publishers, New Delhi, 2007.

Reference Books:

1. Chetan singh Solanki ,Renewable energy technologies, PHI learning private limited
2. Khan B H, Non-conventional energy resources, TMH, New Delhi, 2006
3. Mukherjee D & Chakraborti *S*, Fundamentals of Renewable Energy Systems, New Age International Publishers, 2005.

Course Title	**Electrical Engineering Materials**		
Course Code	**20EE625**	**L-T-P**	**(3-0-0) 3**
Exam	**3 Hrs.**	**Hours/Week**	**3**
SEE	**50 Marks**	**Total Hours**	**40**

Course Objective: Students will be able to select electrical engineering materials.

Course Outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to PO	Mapping to PSO's
1	Explain the properties, classifications, basic features and electrical engineering applications of conducting and semiconducting materials.	1	1
2	Discuss the classes, origin and application of magnetic materials.	1	1
3	Explain polarization phenomena, parameters characterizing the behaviour of insulating materials.	1	1
4	Describe modern techniques for material studies.	1	1

MODULE-1 **10 Hrs**

Conducting Materials: Review of metallic conduction on the basis of free electron theory, Fermi-Dirac distribution, variation of conductivity with temperature and composition, Materials for electric resistors - General Electric properties; brushes of electrical machines, lamp filaments, fuses and solder.

MODULE-2 **10 Hrs**

Magnetic materials: Classification of magnetic materials, origin of permanent magnetic dipoles, ferromagnetism, hard and soft magnetic materials, Magneto-materials used in electrical machines, instruments and relays.

Dielectrics: Dielectric polarization under static fields – electronic, ionic and dipolar polarizations, behavior of dielectrics in alternating fields, factors influencing dielectric strength and capacitor materials. Insulating materials, complex dielectric constant, dipolar relaxation and dielectric loss.

MODULE-3 **10 Hrs**

Insulating materials: Inorganic materials (mica, glass, porcelain, asbestos), organic materials (paper, rubber, cotton, silk, fibre, wood, plastics and Bakelite), resins and varnishes, liquid insulators (transformer oil), gaseous insulators (Air, SF_6 and Nitrogen) and ageing of insulators.

Materials for special applications: Materials for solar cells, fuel cells and battery. Material coatings for enhanced solar thermal energy collection and solar selective coatings, cold mirror coatings, heat mirror coatings, anti-reflection coatings, sintered alloys for breaker and switch contacts.	
MODULE-4	**10 Hrs**
Modern techniques for material studies: Optical microscopy, Electron microscopy, Photo electron spectroscopy, Atomic absorption spectroscopy, magnetic resonance, nuclear magnetic resonance, electron spin resonance and ferromagnetic resonance. Introduction, properties and application of Piezo-electric materials, Eletrostrictive materials, Ferromagnetic materials, Magnetostrictive materials, Shape memory alloys, Electro archeological fluids, Magneto-archeological fluids, Smart hydrogels. **Ceramics:** Properties, application to conductors, insulator and capacitors. Plastics: Thermoplastics, rubber, thermostats, properties.	
Text books: 1. Ian P. Jones, *Materials Science for Electrical & Electronics Engineering*, 1st Edition, Oxford University Press, 2007.	
Reference Books: 1. A. J. Dekkar, *Electrical Engineering Materials*, 1st Edition, Prentice Hall of India Private Limited, 1983. 2. R. K. Rajput, *Electrical Engineering Materials*, 1st Edition, Laxmi Publications, 1993.	

Open Elective – 1

Course Title	**Basic Power Electronics**		
Course Code	**19OEEE61**	**L-T-P**	**(3-0-0) 3**
Exam	**3 Hrs.**	**Hours/Week**	**3**
SEE	**50 Marks**	**Total Hours**	**40**

Course Objective: Students will be able to analyse and design simple power electronic converters.

Course Outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to PO	Mapping to PSO's
1	Explain the basic switching principle of various power electronic switching devices and their characteristics.	1	2
2	Analyse various techniques used to control the power electronic switching devices.	1,2	2
3	Describe working principle AC & DC voltage controllers for R & RL loads, AC-DC & DC-AC converters.	1,2	2

MODULE-1	**10 Hrs**
Introduction to Power Electronics, Power conditioning systems, Classification, ideal/practical switch characteristics, power semiconductor devices, Applications of power electronics. **Power Diode:** Introduction, V-I characteristics, Reverse Recovery Characteristics, types. **Self Study:** *Selection of power electronic devices of Applications.*	
MODULE-2	**10 Hrs**
Power Transistors: Power MOSFETs (n channel enhancement type MOSFET) – Structure, Switching characteristics, Necessity of isolation, Isolation techniques, Gate drive requirements. IGBT- Structure.	

Thyristors: Types, Characteristics, Turn-on and turn-off, Thyristor firing circuits (RC firing, UJT firing). **Self Study:** *Digital firing circuits for thyristors.*	
MODULE-3	**10 Hrs**
AC Voltage Controllers: Introduction, Principle of ON-OFF control, Single phase Bi-directional phase controller with resistive loads, Single phase controllers with inductive loads. **DC-DC Converters:** Introduction, Classes of Choppers, step up chopper, step down chopper. **Self Study:** TRIAC-DIAC combination for AC voltage control.	
MODULE-4	**10 Hrs**
Controlled Rectifiers: Introduction principle & operation of phase controlled converter, single-phase full converter (RL load), single-phase dual converter (RL load), 3-phase full converters (R load). **Inverters:** Introduction, Single-phase bridge inverters, 3-phase bridge inverter. **Self Study:** Significance of Harmonic reduction and power factor improvement in power electronic converters.	
Text books: 1. M.H. Rashid, *Power Electronics,* 2nd edition, Prentice Hall of India Pvt. Ltd., New Delhi, 2002.	
Reference Books: 1. M D Singh & Kanchandani, *Power Electronics*, TMH publishing company limited, Reprint 2001. 2. Dr. P.S. Bimbhra, *Power Electronics*, Khanna Publishers 1996.	

Course Title	**Alternate Energy Sources**		
Course Code	**19OEEE62**	**L-T-P**	**(3-0-0) 3**
Exam	**3 Hrs.**	**Hours/Week**	**3**
SEE	**50 Marks**	**Total Hours**	**40**

Course Objective: Students will analyse and design the renewable energy conversion system components for real time application

Course Outcomes: At the end of course, student will be able to:

#	**Course Outcomes**	**Mapping to PO**	**Mapping to PSO's**
1	Explain basics of renewable energy sources such as solar wind, tidal etc.	1,6,7	1
2	Describe the concepts of the real time solar PV, Solar thermal and Solar Electric Systems.	1,2,6,7	1
3	Design solar and wind energy system parameters.	1,2,3,7	1

MODULE-1	**10 Hrs**
Energy Sources: Renewable energy resources-classifications, advantages, limitations; comparison of conventional & non-conventional energy resources. **Environmental and Ecological Effects of Energy Production and Consumption**: The Greenhouse Effect, Major Consequences of the Greenhouse Effect, Remedial Actions for Global Warming **Solar Energy Basics:** Solar constant, Basic sun-Earth angles- definitions & their representation, solar radiation geometry, Estimation of solar radiation of Horizontal & Tilted surfaces. **Self Study:** Efficiency of Solar Cells.	
MODULE-2	**10 Hrs**
Solar Thermal Systems: Solar Flat plat collectors-mathematical models for energy gain and thermal efficiency, solar cookers-box type, concentrating dish type, solar driers, still furnaces. **Solar Electric Systems:** solar thermal electric power generation-solar pond & concentrating solar collector (Parabolic trough, Parabolic dish central tower collector) advantages & disadvantages; solar photovoltaic-solar cell fundamentals, characteristics, Environmental Issues of Solar Energy Utilization.	

Self Study: Solar water heater

MODULE-3	10 Hrs

Wind Energy: Introduction, wind & its properties, wind energy scenario-world & India. Basic principles of wind energy conversion systems (WECS), classification of WECS, part of a WECS. Derivation for power in the wind, electrical power output & capacity factor of WECS, wind site selection consideration, advantages & disadvantages of WECS, Future of Wind Power.

Self Study: Efficiency of Wind Turbines

MODULE-4	10 Hrs

Biomass Energy: Introduction photosynthesis process, biomass fuels, biomass conversion technologies, Methods of Biomass Utilization, Biomass gasification, Biomass to Ethanol production, factors Affecting Biogas generation, types of Biogas plants – KVIC & Janata Model, Biofuels, Environmental Effects.

Energy From Ocean: Tidal energy – principle of tidal power, components of tidal power plant (TPP), classification of tidal power plants, Systems for Tidal Power Utilization estimation of energy – single basin, Advantages & Limitation of TPP. Ocean thermal energy conversion (OTEC) principle of OTEC system, methods of OTEC power generation – open cycle (Claude cycle), Closed cycle (Anderson cycle), Environmental Effects of Tidal Systems.

Self Study: Ocean Currents, Wave Power.

Text books:

1. Rai, G D, *Non-conventional sources of energy*, 4^{th} Edition, Khanna publishers, New Delhi, 2007.

Reference Books:

1. Khan B H, *Non-conventional energy resources*, TMH, New Delhi, 2006
2. Mukherjee, D & *Chakraborti S*, *Fundamentals of Renewable Energy Systems,* New Age International Publishers, 2005.