MALNAD COLLEGE OF ENGINEERING, HASSAN

(An Autonomous Institution Affiliated to VTU, Belagavi)

Autonomous Programmes

Bachelor of Engineering

Scheme for

III - VIII Semesters

Academic Year: 2024-25

DEPARTMENT OF

ELECTRICAL AND ELECTRONICS ENGINEERING

Admitted Batch: 2022 – 26

VISION of the Department

To become a department of excellence in the domain of Electrical and Electronics Engineering producing competent engineers with research acumen having moral and social values.

MISSION of the Department

- Enhance industry and alumni interaction.
- Promote continuous quality up gradation of faculty and technical staff.
- Time to time modernization of departmental infrastructure to provide state of the artlaboratories.
- Create research-oriented culture to invoke the desire and ability of lifelong learning amongthe students for pursuing successful career.
- Create and sustain environment of learning in which students acquire knowledge and learn toapply it professionally with due consideration of social and ethical values.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

Graduates of the program will be able to

1. Design, analyze, operate and maintain equipment related to electrical and electronic industrieswith continuous integration with core and allied industries.

2. Use state of art laboratories and modern computer based tools to pursue a diverse range of careeras engineers and researchers.

3. Bring out innovations to provide best solutions to electrical engineering problems.

4. Fulfill the needs of society in solving technical problems using engineering principles, tools andpractices, in an ethical and responsible manner.

PROGRAM OUTCOMES (POs)

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 methodsincluding 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 anunderstanding 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 professionalengineering practice.
7. **Environment and sustainability**: Understand the impact of the professional engineering

solutions insocietal 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 teamwork**: Function effectively as an individual, and as a member or leader in diverseteams, and in multidisciplinary settings.
10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering andmanagement principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning**: Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1: Develop models, design, analyze and assess the performance of different types of electrical machines, control systems and generation, transmission, distribution, protection mechanisms in power systems.

PSO2: 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 electronic systems.

Scheme of Evaluation (Theory Courses)

Assessment	Marks
CIE 1	**10**
CIE 2	**10**
CIE 3	**10**
Activities (Minimum 2)	**20**
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**

MALNAD COLLEGE OF ENGINEERING, HASSAN

Regulations governing the award of B.E. (2022) Scheme

Credit Breakup for a Programme			
Sl. No	Category	Credits(AICTE Breakup)	MCE – Department of EEE
1.	Humanities and Social Sciences including Management courses, including AE	16	18
2.	Basic Science Courses	22	21
3.	Engineering Science course including workshop, drawing,basics of electrical / mechanical / computer / PL /ET etc.	24	17
4.	Professional Core courses relevant to chosen specialization/branch	59	59
5.	Professional Elective courses relevant to chosen specialization/branch	12	12
6.	Open subjects - Electives from other technical and/or emerging subjects	12	15
7.	Project work and internship in industry or elsewhere	15	18
8.	Mandatory Courses	(non-Credit)	-
Total		**160**	**160**

Semester-wise Allocation of Credits

Year	Semester	Credits	Total Credits
I Year	1	20	40
	2	20	
II Year	3	21	42
	4	21	
III Year	5	25	48
	6	23	
IV Year	7	20	30
	8	10	
Total		**160**	**160**

- Lecture (L): one hour/week : 1 credit
- Tutorial (T): Two hours/week : 1 credit
- Practical/Lab/Drawing(P): Twohours/week : 1 credit

The duration for courses: Integrated courses and courses with tutorial can have more teaching hours:

- 4-credits – 50 Hrs
- 3-credits – 40 Hrs
- 2-credits – 25 Hrs
- 1-credit – 15 Hrs

Scheme of Teaching for the 2022-23 Admitted Batch

THIRD SEMESTER					
Course Category and Course Code		**Course Title**	**L-T-P**	**Credits**	**Contact Hours**
BSC	22MA301	Linear Algebra and Integral Transforms	3-1-0	3	4
PCC	22EE302	Analog Electronic Circuits	3-0-0	3	3
PCC	22EE303	Digital Electronic Circuits	3-0-0	3	3
PCC	22EE304	Transformers & Induction Machines	3-0-0	3	3
PCC	22EE305	Transformers & Induction Machines Laboratory	0-0-2	1	2
PCC	22EE306	Electronics Laboratory	0-0-2	1	2
ESC	22ESEE3X	Engineering Science Course - II	3-0-0	3	3
HSMC	22SCR	Social Connect and Responsibility	0-0-2	1	2
BSC	22BE	Biology for Engineers	0-2-0	2	2
AEC	22AEEE3X	Ability Enhancement Course - III	0-0-2	1	2
BSC	22BCM301	Bridge Mathematics-1 (Mandate Audit course for Diploma entry students)	3-0-0	0	3
Total				**21**	**29**

FOURTH SEMESTER					
Course Category and Course Code		**Course Title**	**L-T-P**	**Credits**	**Contact Hours**
PCC	22EE401	Electric Power Generation &Transmission	4-0-0	4	4
PCC	22EE402	Electrical Network Analysis	4-1-0	4	5
IPCC	22EE403	Microcontrollers (Laboratory Integrated)	3-0-2	4	5
IPCC	22EE404	Synchronous and Special Electrical Machines (Laboratory Integrated)	3-0-2	4	5
ETC	22ETC42X	Emerging Technology Course - II	3-0-0	3	3
HSMC	22UHV	Universal Human Values	0-0-2	1	2
AEC	22AEEE4X	Ability Enhancement Course - IV	0-0-2	1	2
BS	22BCM401	Bridge Mathematics-II (Mandate Audit course for Diploma entry students)	0-0-0	0	3
Total				**21**	**29**

Emerging Technology Courses - II			
22ETEE41	Introduction to Renewable Energy Sources	22ETEE43	Python for Electrical Engineers
22ETEE42	Introduction to Electric Vehicle Technology	22ETEE44	Object Oriented Programming with C++
Ability Enhancement Course - IV			
22AEEE41	Statistics with R	22AEEE43	Integrated Circuit Laboratory
22AEEE42	DIGI SIM for Digital Electronics	22AEEE44	Arduino Laboratory

FIFTH SEMESTER					
Course Category and Course Code		**Course Title**	**L-T-P**	**Credits**	**Contact Hours**
HSMC	22EE501	Industrial Management and Professional Engineering Practice	4-0-0	4	4
IPCC	22EE502	Linear Control Systems (Integrated Laboratory)	3-0-2	4	5
PCC	22EE503	Power Electronics	4-0-0	4	4
PCC	22EE504	Electromagnetic Fields	3-0-0	3	3
PCC	22EE505	Power Electronics Laboratory	0-0-2	1	2
AEC	22RIP	Research Methodology & IPR	3-0-0	3	3
PEC	22EE51X	Professional Elective Course - I	3-0-0	3	3
HSMC	22EVS5X	Environmental Studies	0-0-2	1	2
Total				**23**	**26**

Professional Elective Course – I			
22EE511	Energy Auditing & Demand-Side Management	22EE513	Programmable Logic Controllers
22EE512	Digital Signal Processing	22EE514	Operational Amplifiers and Linear ICs

SIXTH SEMESTER					
Course Category and Course Code		**Course Title**	**L-T-P**	**Credits**	**Contact Hours**
PCC	22EE601	Power System Analysis and Stability	4-0-0	4	4
IPCC	22EE602	Electrical Machine Design	3-0-0	3	3
PCC	22EE603	High Voltage Engineering	3-0-0	3	3
PCC	22EE604	Switchgear and Protection	3-0-0	3	3
PEC	22EE62X	Professional Elective Course - II	3-0-0	3	3
OEC	22OEEX6X	Open Elective – I	3-0-0	3	3
PI	22PROJ6X	Project Work Phase - I	0-0-4	2	4
PEC	22SW01	SWAYAM - I	0-1(A)-0	Audit	--
AEC	22ASK	Analytical ability & soft skills	0-0-2	1	2
Total				**22**	**25**

Professional Elective Course – II			
22EE621	Battery Energy Storage Systems	22EE623	Smart Grid Technologies
22EE622	Testing & commissioning of Electrical equipment	22EE624	Renewable Energy Systems
Open Elective – I			
22OEEE61	Basic Power Electronics	22OEEE62	Alternate Energy Sources

SEVENTH SEMESTER					
Course Category and Course Code		**Course Title**	**L-T-P**	**Credits**	**Contact Hours**
IPCC	22EE701	Computer Methods in Power Systems(Integrated Laboratory)	3-0-2	4	5
IPCC	22EE702	Solar Photovoltaic Systems (Integrated Laboratory)	3-0-2	4	5
PCC	22EE703	Relay and High Voltage Laboratory	0-0-2	1	2
PEC	22EE73X	Professional Elective Course - III	3-0-0	3	3
PEC	23EE74X	Elective -IV (Industry Elective)	1-0-0	1	1
OEC	22OEEX7X	Open Elective -II	3-0-0	3	3
PI	22PROJ	Project Work Phase II	0-0-8	4	8
Total				**20**	**27**

Professional Elective Course – III			
22EE731	Fuzzy Logic Control	22EE733	Flexible AC Transmission Systems
22EE732	Modern Control Theory	22EE734	Electrical Power Quality
Open Elective – II			
22OEEE71	Smart Grid Technologies	22OEEE71	Utilization of Electric Power

EIGHTH SEMESTER					
Course Category and Course Code		**Course Title**	**L-T-P**	**Credits**	**Contact Hours**
PEC	22SW02	Professional Elective (Online Courses) Only through NPTEL - SWAYAM - II		3	12 (weeks)
PI	22INT3	Internship (Industry/ Research) (14-20 weeks)	0-0-20	10	20
Total				**13**	**20**

V SEMESTER

Course Title	INDUSTRIAL MANAGEMENT AND PROFESSIONAL ENGINEERING PRACTICE		
Course Code	22EE501	(L-T-P) C	(4-0-0) 4
CIE	50	Hours/Week	4
SEE	50	Total Hours	52

Course Objective: To acquire and apply managerial skills with ethics in engineering practice.

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

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1	Interpret various functions of management and emerge as a productive member of society.	1,6,12	1
2	Assess familiarity on structure of the organization in present day scenario.	1, 6,12	1
3	Discuss characteristics of Engineering Profession, Professional responsibility and Rules of Practice	1, 8, 11, 12	1
4	Describe the concepts of Project management and apply project management tools and techniques.	1, 11, 12	1

Course Articulation Matrix

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2					3			2			2	2	
CO2	2					1						1	2	
CO3	3					2	2	3	2	1	3	3	2	
CO4	3										3	3	2	

MODULE-1 — 13 Hrs

Introduction to Management: Managers and their work, Management Functions, Mintzberg's Managerial Roles and a Contemporary Model of Managing, Management Skills, Management history- Early, classical, behavioural, quantitative and contemporary approaches. Managers as decision makers: decision making process, types of decision making, decision making styles and effective decision making in today's world.

SLC: Strategic management.

MODULE-2 — 13 Hrs

Functional areas of management: Planning-goals and plans, types of goals and plans, setting goals and developing plans. Organizing- Designing organizing structure, work specialization, departmentalization, span of control, centralization and decentralization. Controlling-the control process. Motivation-Early and contemporary theories of motivation. Leadership-Early and contingency theories of leadership.

SLC: Green management and sustainability.

MODULE-3 — 13 Hrs

Professional Engineering Practice: Introduction, characteristics of a profession, The Engineering Profession, licence, professional responsibility, The Engineer's duty to report, Rules of Professional Engineering Practice, certificate of authorisation, advertising, Professional Standards.

SLC: Professional engineering bodies in India.

MODULE-4 — 13 Hrs

Project management: Introduction, Understanding Project Management, Defining Project Success, The Project Manager–Line Manager Interface, Defining the Project Manager's Role, Defining the functional Manager's Role, Defining the Functional Employee's Role, Defining the Executive's Role, The Downside of Project Management. Time management and stress: Introduction, Understanding Time Management, Time Robbers, Time Management Forms, Effective Time Management, Stress and Burnout.

SLC: Effective Project Management in the Small Business Organization

Text books:

1. Management by Stephen P Robinns, Prentice Hall
2. Professional Engineering Practice: Professional engineers Ontario, 101-40 Sheppard Avenue West Toronto ON M2N 6K9.

Reference Books:

1. Project Management: A Systems Approach to Planning, Scheduling, and Controlling. Harold K

Course Title	**LINEAR CONTROL SYSTEMS**		
Course Code	**22EE502**	**(L-T-P) C**	**(3-0-2) 4**
CIE	**50**	**Hours/Week**	**5**
SEE	**50**	**Total Hours**	**64 (40L + 24P)**

Course Objective: Students will learn to model and analyze Linear 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	Apply fundamental knowledge of modelling of electrical and mechanical systems.	1,2,5	1
2	Analyse time response specifications of second order systems.	1,2,5	1
3	Analyse the stability of a system using R-H criteria, root locus and frequency domain analysis.	1,2,5	1
4	Discuss the basic parameters of P, PI, PD and PID Controllers and compensating networks.	1,2,5	1

Course Articulation Matrix

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1		2								2	
CO2	3	2	1		2								2	
CO3	2	3	1		2								2	
CO4	2	3	1		2								2	

MODULE-1 **10 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 and mechanical systems.

SLC: Electro-mechanical systems.

MODULE-2 **12 Hrs**

Block Diagrams and Signal Flow Graphs: Block diagram representation and reduction, Signal flow graph representation and reduction using Mason's gain formula.

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.

SLC: Transient response of a higher order system.

MODULE-3 **08 Hrs**

Stability Analysis: Bounded input and bounded output stability, zero input and asymptotic stability, Methods of determining stability, Routh-Hurwitz criterion.
Root Locus Techniques: Root locus concepts, Rules for construction of root loci, Stability analysis.
SLC: Effects of Addition of Poles and Zeros, Root Contour.

MODULE-4	**10 Hrs**

Frequency Domain Analysis: Bode plots, Gain and phase cross over points, Frequency domain specifications. Resonant peak, resonant frequency and bandwidth.
Methods to Improve Time Response: P, PI, PD and PID Controllers. Introduction to compensating networks.
SLC: Phase-Lead and Phase-Lag Compensator.

Laboratory Component	**24 Hrs**

1. Simulation of electrical and mechanical system using MATLAB/SIMULINK.
2. Block Diagram Reduction of Linear Systems using MATLAB.
3. Simulation of a typical second order system and determination of step response and evaluation of time-domain specifications using MATLAB.
4. Analysis on the effect of variation of damping ratio in a typical second order system using MATLAB.
5. Analysis of stability of the system using MATLAB simulation of Root loci of a given transfer function.
6. Analysis of stability of the system using MATLAB simulation of Bode plot of a given transfer function.
7. Compare the effect of P, PI and PD controller on the step response of a feedback control system using MATLAB.

Text Book:
1. Nagrath and Gopal, Control System Engineering, New Age Internal, 7th Edition, 2021.

Reference Books:
1. K. Ogata, Modern Control Engineering, PHI/Pearson Education, 5th Edition, 2009.
2. B. C. Kuo, Automatic Control Systems, PHI, 7th Edition, 2002.
3. Smarajit Ghosh, Control Systems: Theory and Application, Pearson Education, 2nd Edition, 2012.

Course Title	**POWER ELECTRONICS**		
Course Code	**22EE503**	**(L-T-P) C**	**(4-0-0) 4**
CIE	**50**	**Hours/Week**	**4**
SEE	**50**	**Total Hours**	**52**

Course Objective: To design suitable power electronic converter for an application.
Course outcomes: At the end of course, student will be able to:

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1	Explain the fundamental concepts of power electronic converters.	1	2
2	Explain the basic principles of various power electronic converters and their characteristics.	1	2
3	Apply power electronics principles for obtaining the performance parameters of various types of converters.	1,2	2
4	Analyze the performance parameters of various power electronic converters.	1,2	2

Course Articulation Matrix

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3													2
CO2	3													2
CO3	2	3												2
CO4		2												2

MODULE-1	**13 Hrs**

Introduction to power electronics, classification of power electronic devices & converters, peripheral effects.
Power Transistors: Power MOSFETs (n channel enhancement type MOSFET) – structure, switching characteristics, IGBT- structure, necessity of isolation in power transistor circuits, Isolation techniques.
Thyristors: Structure of SCR, V-I characteristics, two transistor model of SCR, turn-on and turn-off, di/dt and dv/dt protection, Thyristor firing circuits (RC half wave and full wave triggering, UJT triggering.
SLC: V-I characteristics of DIAC, TRIAC & GTO.

MODULE-2	**13 Hrs**

Controlled Rectifiers: Introduction, Principle of Phase control, single-phase semi converter (RL load), single-phase full converter (RL load), single-phase dual converter (RL load), three-phase half wave converters (R load, No problems).
AC Voltage Controllers: Introduction, Principle of on-off control, single phase bi-directional controller with R & RL loads.
SLC: Applications of controlled rectifiers and AC voltage controllers.

MODULE-3	**13 Hrs**

DC-DC Converters: Introduction, step-down (buck) converter, Analysis of step-down converter for R, RL & RLE loads, step-up (boost) converter, Control strategies. Full-bridge chopper (Class E) and multi-quadrant operation. Comparison of DC-DC converters.
SLC: Applications of DC-DC converters.

MODULE-4	**13 Hrs**

Inverters: Introduction, **Single-phase inverters:** Single-phase half bridge inverters, performance parameters, single-phase bridge inverters, Voltage control of single-phase inverters: single-pulse-width modulation (PWM), Multiple PWM, Sinusoidal PWM, **Three phase Inverters:** 180-degree conduction, Voltage control of three phase inverters: Sinusoidal pulse width modulation and space vector modulation.
SLC: Applications of Inverters.

Text books:

1. M.H. Rashid, Power Electronics, 4th edition, Pearson, 2014.
2. Ned Mohan, Power Electronics, Wiley, 2007.

Reference Books:

1. Joseph Vithyathil, Power Electronics Principles and Applications, Tata Mcgraw Hill, 2010.
2. P.S. Bimbhra, Power Electronics, Khanna Publishers, 2018.

Course Title	ELECTROMAGNETIC FIELDS		
Course Code	22EE504	(L-T-P) C	(3-0-0) 3
CIE	50	Hours/Week	3
SEE	50	Total Hours	40

Course Objective: To apply the knowledge of electromagnetic fields in diverse areas of electrical engineering.

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

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1	Explain the fundamental laws in the area of electric field, magnetic field and time varying electromagnetic field.	1,2	1
2	Analyze various static charge configurations in the electrostatic fields.	1,2,5	1
3	Analyze steady current configurations in the magnetostatic fields.	1,2,5	1
4	Apply concepts of time varying electromagnetic fields for basic systems.	1,2,5	1

Course Articulation Matrix

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2											2	
CO2	3	3			2								2	
CO3	2	3			2								2	
CO4	2	3			2								2	

MODULE-1 — 10 Hrs

Electrostatics: 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 - Statement, Equations of divergence in cartesian, cylindrical and spherical co-ordinates, Divergence theorem.

MODULE-2 — 10 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.

MODULE-3 — 10 Hrs

Capacitance and examples, Poisson's and Laplace's equations, examples on Laplace's equation.

Magnetostatics: Steady magnetic field, Biot-Savart's law, Ampere's circuit law, Curl, Stoke's theorem - Statement, Magnetic flux and flux density, Maxwell's equations for static fields.

MODULE-4 — 10 Hrs

Force on a moving charge – Lorentz force equation, Force on a differential current element, force on a straight current carrying conductor, force on differential current carrying loops. 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 ELECTRONICS LABORATORY		
Course Code	22EE505	(L-T-P) C	(0-0-2) 1
CIE	50	Hours/Week	2
SEE	50	Total Hours	24

Course Objective: To demonstrate the ability to work with various power electronic circuits.

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

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1	Conduct experiments to understand the static characteristics of Power Electronic devices.	1,2,9,10	2
2	Drive power electronic devices and converters using gate drive circuits.	1,2,9,10	2
3	Demonstrate the working of power electronic converters to drive different loads.	1,2,5,9,10	2

Course Articulation Matrix

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2						-	2	2				2
CO2	3	2						-	2	2				2
CO3	2	3						-	2	2				2

List of Experiments

1. Static V-I characteristics of SCR.
2. Static V-I characteristics of TRIAC.
3. Static V-I characteristics of MOSFET.
4. Generation of firing signals for SCR using UJT relaxation oscillator.
5. Generation of firing signals for SCR using digital firing circuit.
6. Controlled HWR and FWR using RC Triggering circuit for resistive Load.
7. AC voltage controller using TRIAC-DIAC combination for R & RL loads.
8. DC-DC Step-down (Buck) converter for R load.
9. DC-DC Step-up (Boost) converter for R load.
10. Control of stepper motor in half step and full step mode.
11. Output voltage control of single phase inverter for resistive load.

Course Title	RESEARCH METHODOLOGY & IPR		
Course Code	22RIP	(L-T-P) C	(3-0-0) 3
CIE	50	Hours/Week	3
SEE	50	Total Hours	40

Course Objective: To give an overview of technical research activities and patenting methodology.

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

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1	Carry out Literature Review and write technical paper	2,3,4,8,12	-
2	Describe the fundamentals of patent laws and the patent drafting procedure.	6,8,10,12	-
3	Elucidate the copyright laws and subject matters of copyright	6,8, 10,12	-

Course Articulation Matrix

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1		3	2	3				2				3		
CO2						3		2		3		3		
CO3						3		2		3		3		

MODULE-1 — 10 Hrs

Introduction: Meaning of Research, Objectives of Engineering Research, and Motivation in Engineering Research, Types of Engineering Research. **Ethics in Engineering Research:** Ethics in Engineering Research Practice, Types of Research Misconduct, Ethical Issues Related to Authorship.

Literature Review and Technical Reading, New and Existing Knowledge, Analysis and Synthesis of Prior Art, Bibliographic Databases, Web of Science, Google and Google Scholar, Effective Search: The Way Forward, Introduction to Technical Reading Conceptualizing Research, Critical and Creative Reading.

MODULE-2 — 10 Hrs

Attributions and Citations: Giving Credit Wherever Due, Citations: Functions and Attributes, Impact of Title and Keywords on Citations, Knowledge Flow through Citation, Citing Datasets, Styles for Citations, Acknowledgments and Attributions.

Technical Writing and Publishing : Free Writing and Mining for Ideas, Attributes and Reasons of Technical Writing, Patent or Technical Paper?—The Choice, Writing, Journal Paper: Structure and Approach: Title, Abstract, and Introduction, Methods, Results, and Discussions, Table, Figures, Acknowledgments, and Closures

MODULE-3 — 10 Hrs

Introduction To Intellectual Property: Role of IP in the Economic and Cultural Development of the Society, IP Governance, IP as a Global Indicator of Innovation, Origin of IP, Major Amendments in IP Laws and Acts in India.

Patents: Conditions for Obtaining a Patent Protection, To Patent or Not to Patent an Invention. Rights Associated with Patents. Enforcement of Patent Rights. Inventions Eligible for Patenting. Non- Patentable Matters. Patent Infringements.

Process of Patenting: Prior Art Search. Choice of Application to be Filed. Patent Application Forms. Jurisdiction of Filing Patent Application. Publication. Pre-grant Opposition. Examination. Grant of a Patent. Validity of Patent Protection. Post-grant Opposition. Do I Need First to File a Patent in India. Patent Related Forms. Fee Structure. Types of Patent Applications.

MODULE-4 — 10 Hrs

Copyrights and Related Rights: Classes of Copyrights. Criteria for Copyright. Ownership of Copyright. Copyrights of the Author. Copyright Infringements. Copyright Infringement is a Criminal Offence. Copyright Infringement is a Cognizable Offence. Copyrights and Internet. Non-Copyright Work. Copyright Registration.

Judicial Powers of the Registrar of Copyrights. Fee Structure. Copyright Symbol. Validity of Copyright. Copyright Profile of India. Copyright and the word 'Publish'. Transfer of Copyrights to a Publisher. Copyrights and the Word 'Adaptation'. Copyrights and the Word 'Indian Work'. Joint Authorship. Copyright Society. Copyright Board. Copyright Enforcement Advisory Council (CEAC).

Trademarks: Eligibility Criteria. Who Can Apply for a Trademark. Acts and Laws. Designation of Trademark Symbols. Classification of Trademarks. Registration of a Trademark is Not Compulsory. Validity of Trademark. Types of Trademark Registered in India. Trademark Registry. Process for Trademarks Registration.

Self study: Case Studies on Patents. Case study of Curcuma (Turmeric) Patent, Case study of Neem Patent, IP Organizations In India.

Text books:

1. Dipankar Deb, Rajeeb Dey, Valentina E, Balas, "Engineering Research Methodology", Springer, 2019.
2. Prof. Rupinder Tewari, Ms. Mamta Bhardwa, "Intellectual Property" , Professor Gurpal Singh Sandhu Honorary Director, Publication Bureau, Panjab University, 2021.

Reference Books:

1. David V. Thiel, "Research Methods for Engineers", Cambridge University Press, 2014.
2. N.K.Acharya, "Intellectual Property Rights", Asia Law House, 8th Edition, 2021.

MOOC:

https://onlinecourses.swayam2.ac.in/ntr24_ed08/preview

PROFESSIONAL ELECTIVE COURSE – I

Course Title	ENERGY AUDITING AND DEMAND SIDE MANAGEMEMT		
Course Code	22EE511	(L-T-P) C	(3-0-0) 3
CIE	50	Hours/Week	3
SEE	50	Total Hours	40

Course Objective: To perform energy auditing using various techniques to meet effective energy consumptions.

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

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1	Enhance the knowledge relating to energy, situation of energy and its consumption.	1,12	-
2	Analyse the elements of energy auditing and electrical system optimization.	1,2	-
3	Explain the concept of demand side management and apply its techniques.	1,2,7	-
4	Explain about the energy efficient motors, electrical tariff, lighting basics and load priority techniques	1,	

Course Articulation Matrix

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1											2		
CO2	1	2												2
CO3	1	2					2							2
CO4	1						3						1	1

MODULE-1	10 Hrs

Introduction: Energy Sources, Different types and its applications. Energy situation – world and India,energy consumption, conservation. Payback analysis, Depreciation (Problems)

SLC : Electrical codes and Standards.

MODULE-2	10 Hrs

Energy Auditing: Introduction, Elements of energy audits, energy use profiles, measurements in energyaudits, presentation of energy audit results.

Electrical System Optimization: The power triangle, Motor horsepower, Power flow concept. Electrical Equipment and power factor –correction.

SLC: Location of capacitors.

MODULE-3	10 Hrs

Demand Side Management: Introduction to DSM, concept of DSM, benefits of DSM, different techniquesof DSM – time of day pricing, multi-utility power exchange model, time of day models for planning.

SLC: DSM based on season

MODULE-4	10 Hrs

Energy efficient motors: Lighting basics, Electrical rate tariff. Load management, Load priority technique,Peak clipping, Peak shifting, Valley filling, Strategic conservation, energy efficient equipment.

SLC: Seasonal pricing of Tariff

Text books:

1. Larry C. White, Philip S. Schmidt, David R. Brown, Industrial Energy Management Systems, Hemisphere Publishing Corporation, New York.
2. Albert Thumann, Fundamentals of Energy Engineering, Prentice Hall Inc, Englewood Cliffs, NewJersey.

Reference Books:

1. D.P.Sen, K.R.Padiyar, Indrane Sen, M.A.Pai, Recent Advances in Control and Management of Energy Systems, Interline Publisher, Bangalore, 1993.
2. Jyothi Prakash, Demand Side Management, TMH Publishers
3. Hand book on energy auditing - TERI (Tata Energy Research Institute).

Course Title	DIGITAL SIGNAL PROCESSING		
Course Code	22EE512	(L-T-P) C	(3-0-0) 3
CIE	50	Hours/Week	3
SEE	50	Total Hours	40

Course Objective: To design and implement digital filter for signal processing applications.

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

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

Course Articulation Matrix

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	2	1											2
CO2	1	2	1											2
CO3	1	2	3											2
CO4	1	2	3											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.

SLC: Proofs of different Properties of DFTs.

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 and Parallel form.

SLC: Realization of IIR system in Cascade 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.

SLC: Lattice structure realization of FIR Filter.

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, Design of Linear phase FIR filter using rectangular and Hamming windows. Design of Linear phase FIR filter using Frequency sampling technique.

SLC: Design of Linear phase FIR filter using Kaiser Window.

Text books:

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

Reference Books:

2. Johnny R. Johnson, Introduction to Digital Signal Processing, PHI, 2003.
3. B. Somanathan Nair, Digital Signal Processing, PHI, 2003.
4. P. Ramesh Babu, Digital Signal Processing, Fourth Edition, SciTech Publications, 2011.
5. A. Nagoor Kani, Digital Signal Processing, Second Edition, McGraw Hill Education (India) Private Ltd., 2012.

Course Title	PROGRAMMABLE LOGIC CONTROLLERS		
Course Code	22EE513	(L-T-P) C	(2-0-2) 3
CIE	50	Hours/Week	4
SEE	50	Total Hours	52 (26L+26P)

Course Objective: To develop PLC programs for industrial applications.

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

#	Course Outcomes	Mapping to POs	Mapping to PSOs
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	1,2,3,5	2

Course Articulation Matrix

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3				3									2
CO2	3				3									2
CO3	1	3	3		3									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.

SLC: 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.

SLC: 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.

SLC: 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.

SLC: Timers with counters

Laboratory Components	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.

Course Title	**OPERATIONAL AMPLIFIERS AND LINEAR ICS**		
Course Code	**22EE514**	**(L-T-P) C**	**(3-0-0) 3**
CIE	**50**	**Hours/Week**	**3**
SEE	**50**	**Total Hours**	**40**

Course Objective: To design op-amp based electronic circuits for different applications.

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

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1	Analyze Op-Amp based AC amplifiers.	1	2
2	Realize signal conditioning electronic circuits using Op-Amp.	1	2
3	Develop Op-Amp based non-linear electronic circuits.	1,2	2
4	Design electronic circuits to generate waveforms and filter noises using Op-Amp.	1,2,3	2

Course Articulation Matrix

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1												2
CO2	3	1												2
CO3	3	2												2
CO4	3	2	1											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.

SLC: Fundamentals of Op-amps and ICs

MODULE-2 **10 Hrs**

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

SLC: 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.

SLC: 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.
SLC: 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	**ENVIRONMENTAL STUDIES**		
Course Code	**22EVS5X**	**(L-T-P) C**	**(0-0-2) 1**
CIE	**100**	**Hours/Week**	**2**
SEE	**-**	**Total Hours**	**20**

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 POs	Mapping to PSOs
1	Acquire an awareness of sensitivity to the total environment and its allied problems.	7, 9,12	--
2	Develop strong feelings of concern, sense of ethical responsibility for the environment and the motivation to act in protecting and improving it.	6,8	--
3	Analyze and evaluate environmental measures in real world situations in terms of ecological, political, economical, societal and aesthetic factors.	6, 7,8, 9	--

Course Articulation Matrix

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1							3		3			3		
CO2						3		3				2		
CO3						3	3	3	2					

MODULE-1	**5 Hrs**

Environment: Definition, Ecosystem, Balanced ecosystem, Effects of human activities on environment Agriculture Housing Industry Mining and Transportation.

MODULE-2	**5 Hrs**

Natural Resources: Water resources, Availability and Quality, Water borne diseases, Water induced diseases, Fluoride problem in drinking water. Mineral Resources - Forest Resources - Material Cycles - Carbon, Nitrogen and Sulphur Cycles.

MODULE-3	**5 Hrs**

Pollution: Effects of pollution - Water pollution - Air pollution Land pollution - Noise pollution.

MODULE-4	**5 Hrs**

Current Environmental issues of importance: Acid Rain, Ozone layer depletion - Population Growth, Climate change and Global warming. Environmental Impact Assessment and Sustainable Development Environmental Protection - Legal aspects. Water Act and Air Act.

Text books:

1. Environmental Studies - Dr. D.L Manjunath, Pearson Education -2006
2. Environmental Studies - Dr. S. M. Prakash - Elite Publishers - 2006

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. Meenakshi, "Environmental Science and Engineering", Prentice Hall India.

Assessment Strategy

CIE	Schedule	Assessment Method	Marks	Duration (Min.)
CIE I	At the end of 8 weeks	Objective Questions	25	60
CIE II	At the end of 11 weeks	Objective Questions	25	60
Project	At the end of 14 weeks	Presentation/Role Play/Prototype development	50	-

VI SEMESTER

Course Title	POWER SYSTEM ANALYSIS AND STABILITY		
Course Code	22EE601	(L-T-P) C	(4-0-0) 4
CIE	50	Hours/Week	4
SEE	50	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 POs	Mapping to PSOs
1	Explain the concepts of symmetrical and unsymmetrical faults and stability studies.	1	1
2	Obtain positive, negative and zero sequence reactance diagram for a given Electrical Power system.	1	1
3	Model simplified reactance diagram for the power system network.	2	1
4	Solve various numerical examples for fault and stability analysis of given Electrical Power system.	2	1

Course Articulation Matrix

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3												3	
CO2	3												3	
CO3		3											3	
CO4		2											2	

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, 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, based on various Short circuit studies , illustrative examples.

SLC: Advantages of Y_{Bus} method ROI, Selection of circuit breakers

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, 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, illustrative examples.

SLC: Phasor Algebra, Concept of neutral impedance, obtaining the equivalent sequence diagrams at the point of fault.

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 Z_f, 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. Illustrative examples.

SLC: Open conductor faults in power systems: Single conductor open faults & two conductors open faults.

MODULE-4	**13 Hrs**

Stability Studies: Steady state stability, Dynamic stability and Transient Stability, Definitions, stability margins, 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.

SLC: Bad effects of Instability

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	**ELECTRICAL MACHINE DESIGN**		
Course Code	**22EE602**	**(L-T-P) C**	**(3-0-0) 3**
CIE	**50**	**Hours/Week**	**3**
SEE	**50**	**Total Hours**	**40**

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 POs	Mapping to PSOs
1	Explain the basic principles of electrical machine design and design considerations.	1,2	1
2	Discuss the constructional details of various electrical machines.	1,2	1
3	Apply mathematical relations to derive basic relations for electrical machine design.	1,2	1
4	Evaluate the design parameter using design data handbook.	1,2	1

Course Articulation Matrix

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1												3
CO2	3	2												3
CO3	3	2												3
CO4	3	2												3

MODULE-1	**10 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.

SLC: Different types of windings, General arrangement of windings

MODULE-2	**10 Hrs**

Estimation of number of turns and cross sectional area of Primary and secondary coil, 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.

SLC: Leakage reactance calculation of transformers.

MODULE-3	**10 Hrs**

Estimation of dimension of the slot Rotor design, Length of the air gap, Types of rotor, Design of squirrel cage rotor, design of Rotor bars and end ring.

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.

SLC: Study of different types of prime movers

MODULE-4	**10 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

SLC: 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 Books:

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	**HIGH VOLTAGE ENGINEERING**		
Course Code	**22EE603**	**(L-T-P) C**	**(3-0-0)3**
CIE	**50**	**Hours/Week**	**3**
SEE	**50**	**Total Hours**	**40**

Course Objective: To learn the technology associated in high voltage generation, measurement and testing.

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

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1	Explain the classification, need to generate high voltages and applications of high voltages.	1	1
2	Demonstrate fundamental knowledge of gaseous insulation and theoretically analyze criterion for electrical breakdown of gaseous insulating media.	1,2	1
3	Describe the techniques of generating HVAC, HVDC, Lightning & Switching impulse voltage and current.	1,2	1
4	Explain measurement of high voltages, high currents and high voltage surges.	1,2	1

Course Articulation Matrix

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2												2	
CO2	2	3											2	
CO3	2	3											2	
CO4	2	3											2	

MODULE-1	**10 Hrs**

Introduction: Introduction to HV technology, Advantages of electric power transmission at high voltages. Need for generating high voltages in a laboratory. Important applications of high voltages. Types of HV insulators, cables and bushings.

Breakdown phenomena: Classification of HV insulating media. Gaseous dielectrics: Ionization: Primary and secondary ionization processes. Criterion for gaseous insulation breakdown based on Townsend's theory. Limitations of Townsend theory, Streamer theory, Corona discharges. Breakdown in electronegative gases. Paschen's law and its significance. Time lags of breakdown.

SLC: Solid insulating media

MODULE-2	**10 Hrs**

Generation of High voltage AC and DC: HVAC - HV transformer; Need for cascade connection and working of transformers units connected in cascade. Series resonant circuit - Principle of operation and advantages. Tesla coil. HVDC - Voltage doubler circuit. Cockcroft-Walton type high voltage DC set. Calculation of Voltage regulation, Ripple and Optimum number of stages for minimum voltage drop.

SLC: Potential dividers - Resistance dividers, Capacitance divider.

MODULE-3	**10 Hrs**

Generation of Lightning Impulse voltages: Introduction to standard Lightning Impulse (LI) voltages and necessity of generating them in a laboratory. Analysis of single stage impulse generator – Deriving impulse voltage expression representing a double exponential wave.

Multistage IG and Generation of LI & SI voltages: Multistage impulse generator working on Marx principle. Rating of a Multistage impulse generator. Components of Multistage impulse generator.

SLC: Air blast circuit breaker, Vacuum circuit breaker

MODULE-4	**10 Hrs**

Measurement of high voltages, currents and surges: Electrostatic voltmeter - Principle, construction and limitations. Chubb and Fortescue method for HVAC measurement. Generating voltmeter - Principle and construction. Standard sphere gap for measurement of various types of high voltages; Factors affecting the measurements. Potential dividers - Resistance dividers, Capacitance divider, Mixed RC potential divider. Surge measurement - Klydanograph and magnetic links, Introduction to Partial discharges (PD), PD measurement.

SLC: Solid state relay, microprocessor based relay, Bucholoz relay

Text books:

1. M. S. Naidu and V. Kamaraju, High Voltage Engineering, 4th edition, Tata McGraw Hill, 1995.
2. C. L. Wadhwa, High Voltage Engineering, New Age International Private Limited, 1995.

Reference Books:

1. E. Kufell and W.S. Zaengl, High Voltage Engineering Fundamentals, 2nd Edition, Pergamon Press, 1984.

Course Title	SWITCHGEAR AND PROTECTION		
Course Code	22EE604	(L-T-P) C	(3-0-0) 3
CIE	50	Hours/Week	3
SEE	50	Total Hours	40

Course Objective: To recognize and explain switch gear devices.

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

#	Course Outcomes	Mapping to POs	Mapping to PSOs
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.	1,2	1
4	Describe the different types of distributors and analyze them.	1,2	1

Course Articulation Matrix

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2											2	
CO2	2	2											2	
CO3	3	2											2	
CO4	3	2											2	

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 SF6, SF6 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:

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

Reference Books:

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

PROFESSIONAL ELECTIVE COURSE – II

Course Title	BATTERY ENERGY STORAGE SYSTEMS		
Course Code	22EE621	(L-T-P) C	(3-0-0) 3
CIE	50	Hours/Week	3
SEE	50	Total Hours	40

Course Objective: To explore the fundamentals, technologies and applications of battery energy storage systems.

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

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1	Interpret the Battery terminologies and Equivalent-Circuit Models of Lithium-ion Battery.	1,2	1
2	Analyze the different battery energy storage technologies and their relative advantages and disadvantages	1,2	1
3	Apply the role of battery management systems in electric vehicle.	1,2	1

Course Articulation Matrix

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3											2	
CO2	2	3											3	
CO3	3	2											3	

MODULE-1 — 10 Hrs

Introduction to Batteries: Type of battery and its selection, Selection of battery cell and types, Working principle of battery, primary and secondary (flow) batteries, battery performance evaluation methods, major battery chemistries and their voltages- Li-ion battery& Metal hydride battery vs lead-acid battery.

SLC: Ageing, Uncontrolled operating conditions and abuses of Battery

MODULE-2 — 10 Hrs

Selection & sizing of Balance of system for battery energy storage system: Selection sizing of inverter duty transformer, Sizing of BESS container & ventilation arrangement, Selection of ACDB , DCDB and switchgear selection, Selection of DC cable between DC DB to PCU, Selection AC Cable between ACDB to transformer Cable section for PCU and Inverter, Type of Earthing and calculation, Section of string inverter or central inverter, Protection scheme of HT side.

SLC: Battery-pack topology

MODULE-3 — 10 Hrs

Supercapacitors: Working principle of supercapacitor, types of supercapacitors, cycling and performance characteristics, difference between battery and supercapacitors, Introduction to Hybrid electrochemical supercapacitors.

Fuel cell: Operational principle of a fuel cell, types of fuel cells, hybrid fuel cell-battery systems, hybrid fuel cell-supercapacitor systems.

SLC: Benefits of accurate SOC estimates

MODULE-4 — 10 Hrs

Battery energy storage system for transportation: Mechanical Design and Packaging of Battery Packs for Electric Vehicles, Advanced Battery-Assisted Quick Charger for Electric Vehicles, Charging Optimization Methods for Lithium-Ion Batteries, Thermal run-away for battery systems, Thermal management of battery systems, State of Charge and State of Health Estimation Over the Battery Lifespan, Recycling of Batteries from Electric Vehicles.

SLC: Need for health estimates of Battery

Text books:

1. Frank S. Barnes and Jonah G. Levine, Large Energy Storage Systems Handbook (Mechanical and Aerospace Engineering Series), CRC press (2011)
2. Ralph Zito, Energy storage: A new approach, Wiley (2010)

Reference Books:

1. Pistoia, Gianfranco, and Boryann Liaw. Behaviour of Lithium-Ion Batteries in Electric Vehicles: Battery Health, Performance, Safety, and Cost. Springer International Publishing AG, 2018.
2. Robert A. Huggins, Energy storage, Springer Science & Business Media (2010)
3. Francois Beguin and Elzbieta Frackowiak ,"Super capacitors", Wiley, 2013.
4. Doughty Liaw, Narayan and Srinivasan, "Batteries for Renewable Energy Storage", The Electrochemical Society, New Jersy,2010.

Course Title	**TESTING & COMMISSIONING OF ELECTRICAL EQUIPMENT**		
Course Code	**22EE622**	**(L-T-P) C**	**(3-0-0)3**
CIE	**50**	**Hours/Week**	**3**
SEE	**50**	**Total Hours**	**40**

Course Objective: To demonstrate testing and commissioning of various electrical equipment.

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

#	Course Outcomes	Mapping to POs	Mapping to PSOs
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

Course Articulation Matrix

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3					2							3	
CO2	3					2							2	
CO3	3					2							3	

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.

SLC: 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.

SLC: 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.
SLC: 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.
SLC: 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	**SMART GRID TECHNOLOGIES**		
Course Code	**22EE623**	**(L-T-P) C**	**(3-0-0)3**
CIE	**50**	**Hours/Week**	**3**
SEE	**50**	**Total Hours**	**40**

Course Objective: To demonstrate the modernization of Electrical Power Systems and to address Issues in Smart Grid Implementation.

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

#	Course Outcomes	Mapping to POs	Mapping to PSOs
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 analyze 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

Course Articulation Matrix

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3												3	
CO2	3												3	
CO3	3												3	
CO4	3					2							3	

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

SLC: 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. Demand-side integration, Services provided by DSI, Implementations of DSI, Hardware support to DSI implementations.

SLC: Cyber Security for Smart Grid

MODULE-3	**10 Hrs**

Distribution automation equipment: Introduction, Substation automation equipment, Current transformers, Voltage transformers, Intelligent electronic devices, Bay controller, Remote terminal units. Faults in the distribution system: Components for fault isolation and restoration, Fault location, isolation and restoration, Voltage regulation.

Distribution Management System: Data sources and associated external systems-structure and main components, modelling and analysis tools, Applications.

SLC: Computational tools to Smart Grid

MODULE-4	**10 Hrs**

Transmission system operation: Introduction, Data sources, IEDs and SCADA, Phasor measurement units, Energy management systems, Wide area applications , On-line transient stability controller, Pole-slipping preventive controller. **Energy storage**- Introduction, various energy storage technologies. Case study- Agent based control of EV battery charging.

SLC: 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:

1. Bharat Modi, Anu prakash and Yogesh Kumar "Fundamentals of Smart Grid Technology"
2. James Momoh "SMART GRID Fundamentals of Design and Analysis", IEEE press, A John Wiley & Sons, Inc., Publication

Course Title	RENEWABLE ENERGY SYSTEMS		
Course Code	22EE624	(L-T-P) C	(3-0-0)3
CIE	50	Hours/Week	3
SEE	50	Total Hours	40

Course Objective: To analyze the renewable energy technologies for real time application.

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

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1	Understand the various technologies of solar photovoltaic & thermal systems.	1,6,7	1
2	Solve various problems on solar photovoltaic & thermal systems.	2,6,7,12	1
3	Design different components of solar thermal & photovoltaic systems	3, 6,7,12	1
4	Apply modern tools for prediction & modeling of renewable energy systems.	5,12	2

Course Articulation Matrix

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3					2	2						3	
CO2		3				2	2					2	3	
CO3			3			2	2					2	3	
CO4					1							2		2

MODULE-1	10 Hrs

Solar Photovoltaic Technologies: Basic of solar photovoltaic technology – Amount of power generated, generating more power using solar PV. Solar PV system& their components. Solar PV lantern- Design & costing of Solar PV lantern. Solar Standalone PV system-Home lighting & other usage-case study. Solar PV water pumping systems- design of solar PV Pumping system- Case study.

MODULE-2	10 Hrs

Solar Thermal systems & Applications: Review of Flat Plate Collectors- Efficiency of flat plate collectors, numerical problems.

Applications: Solar Water Heater- Components & specification of Solar water heater, Design & Costing solar heating, Installation & Maintenance.

Solar Energy storage: Introduction, Solar energy storage systems-Solar Pond Electric power generation.

MODULE-3	10 Hrs

Applications: Solar cooking systems: Principle of cooking, cooking by boiling, speed of cooking, energy required for cooking (numerical problems). Types of solar cooker- Box, Dish Heat transfer type solar cooker.

Solar Distillation: Water categories, distillation process for water purification, operation of solar distillation. Design of solar still & costing. Parameters affecting solar still performance, Economics of solar still. Maintenance and troubleshooting.

MODULE-4	10 Hrs

Mathematical Modelling of Renewable energy systems: Solar, wind, Biomass/ biogas & battery systems. Integrated renewable energy system for on/off grid Applications. Introductions to Software Tools (HOMER & MATLAB software). Case study for a typical residential/ commercial application- Load assessment & resources assessment.

Text books:

1. Garg, H. P. (2000). Solar energy: fundamentals and applications. Tata McGraw-Hill Education.Sukhatme, S. P., & Sukhatme, S. P. (1996).
2. Sukhatme, S. P., & Sukhatme, S. P. (1996). Solar energy: principles of thermal collection and storage.

Reference Books:

1. Non-conventional sources of energy / by G.D. Rai, New Delhi: Khanna Publishers, 2014.

OPEN ELECTIVE – I

Course Title	BASIC POWER ELECTRONICS		
Course Code	22OEEE61	(L-T-P) C	(2-0-1)3
CIE	50	Hours/Week	3
SEE	50	Total Hours	40 (28L+12P)

Course Objective: To understand & demonstrate simple power converter circuits.

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

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1	Explain the basic principle of various power electronic devices.	1	2
2	Analyze various techniques used to control the devices using power electronic circuits.	1,2	2
3	Describe working principle of various power electronic converters.	1,2	2

Course Articulation Matrix

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3													2
CO2	2	2												1
CO3	2	2												2
CO4	3													2

MODULE-1	7 Hrs

Introduction to Power Electronics, Power conditioning systems, Classification, power electronic device as an ideal switch, ideal switch characteristics, power semiconductor devices, Applications of power electronics.

Power Diode: Introduction, V-I characteristics, types.

SLC: Selection of power electronic devices of Applications.

MODULE-2	7 Hrs

Power Transistors: Power MOSFETs (n channel enhancement type MOSFET) – Structure, Specifications of MOSFETs, Control characteristics.

Thyristors: Types, Characteristics, Turn-on and turn-off methods.

SLC: Firing circuits for thyristors

MODULE-3	7 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 (Block diagram approach only).

DC-DC Converters: Buck converter, Boost Converter, Buck-Boost converter (Block diagram approach only).

SLC: TRIAC-DIAC combination for AC voltage control.

MODULE-4	7 Hrs

Controlled Rectifiers: Introduction, principle & operation of half wave-controlled rectifier, single-phase full wave rectifier for Resistive load, single-phase dual converter for Resistive load (Block diagram approach only).

Inverters: Introduction, Single-phase bridge inverters (Block diagram approach only).

SLC: Applications of rectifiers and inverters

Laboratory Component	12 Hrs

1. Half-wave rectifier circuit for resistive load and C-filter.
2. Bridge rectifier circuit for resistive load and C-filter.
3. Half-wave-controlled rectifier using an SCR.

4. Buck converter circuit with the appropriate components.
5. Single-phase AC voltage controller circuit using a SCR.

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	**22OEEE62**	**(L-T-P) C**	**(3-0-0)3**
CIE	**50**	**Hours/Week**	**3**
SEE	**50**	**Total Hours**	**40**

Course Objective: To understand the concepts of renewable energy systems.

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

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1	Gain the basic knowledge about the basics of renewable energy sources.	1,6,7	1
2	Understand the concept of the real time solar PV, Solar thermal and turbines of wind energy systems.	1,2,6,7	1
3	Able to solve numerical problems on solar and wind energy systems	1,3,6,7	1

Course Articulation Matrix

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3					2	1						2	
CO2	3	2				1	1						2	
CO3	3		2			2	1						2	

MODULE-1 **10 Hrs**

Energy Sources: Classification of energy resources; limitations of non-renewable energy resources, renewable energy resources-classifications, advantages, limitations; comparison of conventional & non-conventional energy resources

Solar Energy Basics: Solar constant, Basic sun-Earth angles- definitions & their representation, solar radiation geometry (Numerical problems) Estimation of solar radiation of Horizontal & Tilted surfaces (Numerical Problems)

SLC: Measurement of solar radiation data – Pyranometer & Pyrheliometer

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, green houses.

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.

SLC: Solar water heater

MODULE-3 **10 Hrs**

Wind Energy: Introduction, wind & its properties, history of wind energy, 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.

SLC: Concept of power co-efficient, tip speed ratio and solidity

MODULE-4	10 Hrs

Biomass Energy: Introduction photosynthesis process, biomass fuels, biomass conversion technologies, Biomass gasification, Biomass to Ethanol production, Bio gas production from waste Biomass, factors Affecting Biogas generation, types of Biogas plants – KVIC & Janata Model.

Energy From Ocean: Tidal energy – principle of tidal power, components of tidal power plant (TPP), classification of tidal power plants, 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)

SLC: Double basin system (simple numerical problems without derivation)

Text books:

1. Rai, G D, Non-conventional sources of energy, 4th 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.