MALNAD COLLEGE OF ENGINEERING, HASSAN

(An Autonomous Institution Affiliated to VTU, Belagavi)

Master of Technology

in

Power and Energy Systems

Scheme & Syllabus

I Semester

DEPARTMENT OF
ELECTRICAL AND ELECTRONICS ENGINEERING
Admitted Batch: 2026-2028

VISION OF THE INSTITUTE

To be an institute of excellence in engineering education and research, producing socially responsible professionals.

MISSION OF THE INSTITUTE

1. Create conducive environment for learning and research
2. Establish industry and academia collaborations
3. Ensure professional and ethical values in all institutional endeavors

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

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

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

Graduates of the program will be able to

PEO 1: Pursue a diverse range of career as engineers and researchers.

PEO 2: Design and develop innovative systems to provide best solutions to electrical engineering problems.

PEO 3: Learn and adapt in a world of constantly evolving technology.

PROGRAM OUTCOMES (POS)

PO 1: **Engineering Knowledge:** Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop to the solution of complex engineering problems.

PO 2: **Problem Analysis:** Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4)

PO 3: **Design/Development of Solutions:** Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required. (WK5)

PO 4: **Conduct Investigations of Complex Problems:** Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (WK8).

PO 5: **Engineering Tool Usage:** Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems. (WK2 and WK6)

PO 6: **The Engineer and The World:** Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment. (WK1, WK5, and WK7).

PO 7: **Ethics:** Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)

PO 8: **Individual and Collaborative Team work:** Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.

PO 9: **Communication:** Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences

PO 10: **Project Management and Finance:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.

PO 11: **Life-Long Learning:** Recognize the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change. (WK8)

KNOWLEDGE AND ATTITUDE PROFILE (WK)

WK1: A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social sciences.

WK2: Conceptually-based mathematics, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline.

WK3: A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline.

WK4: Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.

WK5: Knowledge, including efficient resource use, environmental impacts, whole-life cost, re-use of resources, net zero carbon, and similar concepts, that supports engineering design and operations in a practice area.

WK6: Knowledge of engineering practice (technology) in the practice areas in the engineering discipline.

WK7: Knowledge of the role of engineering in society and identified issues in engineering practice in the discipline, such as the professional responsibility of an engineer to public safety and sustainable development.

WK8: Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues.

WK9: Ethics, inclusive behavior and conduct. Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc. with mutual understanding and respect, and of inclusive attitudes.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO 1: Acquire core competency in analyzing, designing and controlling electrical and electronic systems to meet industrial and societal needs.

PSO 2: Adopt technology by leveraging state-of-the-art and AI tools to develop innovative solutions in emerging areas like renewable energy, electric vehicles and embedded systems.

Scheme of Evaluation (Theory Courses)

Assessment	Marks
CIE 1	**15**
CIE 2	**15**
Activities (Real Time Case Study/Mini Project) **Activity 1 = 10 Mark and Activity 2 = 10 Mark**	**20**
Total CIE+ activity	**50**
SEE	**50**
Total	**100**

Scheme of Evaluation (Laboratory Courses)

Component	Description	Marks
Allotment of marks for regular classwork		
Ability in Conducting Experiments	Initiative, skill, safety practices, teamwork, and independent handling of equipment during regular lab sessions.	10
Laboratory Record / Journal	Regular and neat maintenance of lab record, accuracy of results, and timely submission.	20
	Subtotal	30
Allotment of marks for CIE practical test		
Laboratory Test / Experiment Performance	Ability to set up apparatus, follow procedure, take observations, and obtain correct results in the test experiment.	10
Viva-Voce	Understanding of theory, concepts, and experimental procedure; ability to explain results and answer related questions.	10
	Subtotal	20
	CIE Total	**50**
	SEE	**50**
	CIE + SEE Total	**100**

I SEMESTER												
Sl. No	**Category**	**Course Code**	**Course Title**	**L**	**T**	**P**	**TW+SL**	**Total Hours/Semester**	**CIE**	**SEE**	**Total**	**Credits**
1	MAT	26MPES101	Advanced Engineering Mathematics	42	0	0	48	90	50	50	100	3
2	PCC	26MPES102	Modelling and Analysis of Electrical Machines	42	0	0	48	90	50	50	100	3
3	PCC	26MPES103	Power Electronic Converters	42	0	0	48	90	50	50	100	3
4	PCC	26MPES104	Power Systems Operation, Stability, Protection and Power Quality	56	0	0	64	120	50	50	100	4
5	PCC	26MPES105	Intelligent Embedded Systems for Renewable Energy Systems	42	0	0	48	90	50	50	100	3
6	PEC	26MPES106x	Professional Elective Course-I	42	0	0	48	90	50	50	100	3
7	PCCL	26MPESL107	Energy Laboratory	--	--	28	2	30	50	50	100	1
8	NCMC	26MPES108	Research Methodology and IPR	Teaching and CIE evaluation by CDOE Online Course (online.tvu.ac.in)					100	-	100	PP
Total								**600**	**450**	**350**	**800**	**20**

PROFESSIONAL ELECTIVE COURSE-I			
26MPES1061	Renewable Energy Systems and Grid Integration	26MPES1063	Gas Insulated Systems
26MPES1062	Energy Storage in Power Grids	26MPES1064	Hydrogen Fuel Cells

Overview of Courses, Credits, Projects, and Internships under VTU Curriculum

(A) Abbreviations Adopted in the Scheme of Teaching and Examinations

Course		General Terms			
Acronyms	**Expanded Form**	**Acronyms**	**Expanded Form**	**Acronyms**	**Expanded Form**
AEC	Ability Enhancement Course	AICTE	All India Council for Technical Education	SEE	Semester End Evaluation
ASC	Applied Science Course	CCA	Continuous Comprehensive Assessment	SGPA	Semester Grade Point Average
BSC	Basic Science Course	CGPA	Cumulative Grade Point Average	SL	Self-Learning
HSMC	Humanities Studies and Management Course	CI	Classroom Instruction	SWAYAM	Study Webs of Active-Learning for Young Aspiring Minds
IPCC	Integrated Professional Core Course	CIE	Continuous Internal Evaluation	T	Tutorial
NCMC	Non-Credit Mandatory Course	COE	Centre for Online Education	TW	Term Work
OEC	Open Elective (Interdepartmental or Interdisciplinary) Course	CUL	Cultural	VTU	Visvesvaraya Technological University
PCC	Professional Core Course	NCrF	National Credit Framework	VTU Online	VTU online courses offered by the Centre for Online Education
PCCL	Professional Core Course Laboratory	L	Lecture		
PEC	Professional Elective Course	LI	Laboratory Instruction		
PE	Physical Education	NPTEL	National Programme on Technology Enhanced Learning		
SEC	Skill Enhancement Course	NSS	National Service Scheme		
YOG	Yoga	P	Practical		

(B) Academic Credit Framework in accordance with the National Credit Framework (NCrF)

The National Credit Framework (NCrF), introduced under India's education reforms, serves as an umbrella framework for the creditisation of learning across school education, higher education, vocational education, and experiential learning. NCrF credit levels are determined based on a combination of cumulative years of learning, the complexity of learning outcomes, and the rigor of assessment. These levels signify the degree of competence and complexity attained by the learner, progressing from foundational schooling to advanced doctoral research. Levels 1 to 4 correspond to school education up to the 12th standard, while Levels 4.5 to 8 correspond to higher education, ranging from the undergraduate level to the Ph.D. level. In the earlier system, credits were primarily based on contact time (lecture hours per week × number of weeks per semester/year), assuming that learning is directly proportional to time spent in classroom instruction.

However, the NCrF adopts a comprehensive and outcome-based approach by assigning credits to all forms of learning, including, (i) Classroom teaching, (ii)Laboratory work, (iii)Projects, (iv)Internships and apprenticeships, (v)Online and blended learning, (vi)Fieldwork and community engagement, (vii)Recognition of Prior Learning (RPL), (viii)Sports and arts activities, and (ix)On-the-job training.

Credits are thus based on notional learning hours, representing the total learner effort rather than only contact hours.

This definition aligns Indian education with Global outcome-based credit systems, and international credit transfer practices [e.g., European Credit Transfer and Accumulation System (ECTS)-like frameworks].

According to NCrF, one academic year of learning is equal 1,200 notional learning hours (not a scientifically-validated law or psychological constant, but a policy design hours) and includes classroom teaching, self-study, assignments, projects, laboratory work, co-curricular and extra-curricular activities, internships, apprenticeships and other assessed learning experiences. For these 1,200 hours a student is expected to earn 40 credits, which means 1 credit corresponds to approximately 30 hours of academic learning. Although traditional university systems often equated 1 credit with approximately 13 to15 contact hours per semester, VTU, in alignment with NCrF, considers 14-weeks of structured academic interaction per semester with students is equivalent to approximately 30 notional hours per credit.

The learning methodologies include:

1. Classroom Instruction (CI): Includes different instructional/implementation strategies, such as Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc., to deliver theoretical concepts within the classroom measured in Number of hours per semester.
2. Laboratory Instruction (LI): Expressed as number of hours per semester which Includes experiments/practical performances / problem-based experiences in laboratory, workshop, field or other locations using different instructional / Implementation strategies.
3. Term work (TW): Includes assignments, seminars, presentations, case studies, micro projects, field activities, industrial visits, academic preparation duration and any other student activities in Number of hours per semester.
4. Self-Learning (SL): MOOCs (SWAYAM/NPTEL/Industry certified courses), spoken tutorials, online educational resources, self-initiated projects, Learning through digital resources etc in Number of hours per semester. (If provided in curriculum structure).

VTU, in alignment with NCrF, considers 14-weeks of structured academic interaction per semester with students as equivalent to approximately 30 notional hours per credit. Table below shows the credit structure, equivalent NCrF learning hours adopted by VTU:

Table 7.0.1 VTU Adopted NCrF Credit Structure

Particulars	Classroom Instruction (CI)		Laboratory Instruction (LI)	Term Work (TW) and Self-Learning (SL)	Total Teaching-Learning Hours per Semester
	L	T	P	TW + SL	
1 Credit Theory Course	14	–	–	16	30
1 Credit Practical Course	–	–	28	02	30
2 Credit Theory Course	28	–	–	32	60
3 Credit Theory Course	42	–	–	48	90
3 Credit Theory Course with Tutorial	28	28	–	34	90
4 Credit Theory Course	56	–	–	64	120
4 Credit Theory Course with Tutorial	42	28	–	50	120
4 Credit Integrated Course	42	–	28	50	120
Project Work	–	–	–	As per the type of project	
Internship	–	–	–	As per the type of internship	

NCrF is designed to work with ABC for years, where, credits are digitally stored to accumulate, transfer, and redemption across institutions for vertical and horizontal mobility across sectors, which is essential for MEME.

(C) Details of Courses

(1) Integrated Professional Core Course (IPCC): The Integrated Professional Core Course (IPCC) refers to a core theory course that is integrated with a laboratory of the same subject. Each IPCC carries 4 credits, with Teaching–Learning hours structured (L : T : P) as either (3:0:2). The theory component of the IPCC shall be evaluated through both Continuous Internal Evaluation (CIE) and Semester End Examination (SEE). The laboratory part shall be assessed exclusively through CIE, with no SEE. However, questions derived from the laboratory part may be included in the SEE question paper to ensure comprehensive evaluation.

(2) Non-Credit Mandatory Courses (NCMC): are aimed at enhancing students' knowledge, skills, and awareness beyond the core curriculum. Successful completion of the NCMC is compulsory for fulfilling the requirements of the academic program. It shall not be considered for the computation of SGPA, CGPA and vertical progression. Each student shall register for the prescribed NCMC(s) in the prescribed semester. A student who fails to qualify in the prescribed NCMC shall not be eligible for the conferment of the degree.

(3) Professional Elective Courses (PEC): A professional elective course (PEC) is intended to enhance the depth and breadth of educational experience in the Engineering and Technology curriculum of the same discipline.

(4) Open Elective Courses (OEC): A open elective course (OEC) is a course offered by departments other than a student's parent department. These interdepartmental /interdisciplinary courses allow students to explore disciplines beyond their core area of study. These courses are intended to promote interdisciplinary learning, broad-based education, thereby enhancing a student's overall knowledge, creativity, and employability. Registration to open electives shall be documented under the guidance of the Program Coordinator/ Advisor/Mentor/Proctor.

(5) Ability/Skill Enhancement Course Laboratory (AEC): An Ability Enhancement Course Laboratory is a practical, skill-oriented lab course designed to strengthen students' practical communication, abilities, environmental professional awareness, competencies that support computational thinking, interdisciplinary learning, and application skills through hands-on learning experiences. The laboratory may pertain to disciplinary or interdisciplinary involving experiments, design tasks, and mini-projects aligned with current industry practices.

(6) Skill Enhancement Courses (SEC): These courses are intended to develop specific practical skills and competencies that improve students' employability, technical proficiency, and professional readiness to bridge the gap between academic and industry requirements. These courses emphasize hands-on training, application of theoretical knowledge, and development of discipline-relevant and transferable skills required in industry and society, and develop entrepreneurship and start-up skills.

(7) Online Courses: Online courses are educational programs delivered over the Internet through a digital platform, allowing students to access lessons, assignments, and discussions from anywhere at any time. Most online courses offer flexibility, allowing students to access materials and complete assignments on their own schedule. However, students have to pass the course within a stipulated period as per the norms of the university.

(8) VTU Online Courses: VTU Online Courses are online courses offered by the Centre of Online Education (COE), Mysuru. A wide range of multidisciplinary courses is made available to learners anytime and anywhere, enabling them to earn University-prescribed credits through duly conducted proctored examinations for the award of the degree. NPTEL/SWAYAM courses adopted by VTU shall be offered in accordance with the NPTEL/SWAYAM course delivery framework, wherein teaching–learning is carried out through the online MOOC platform, assignments are administered periodically, and assessment is completed through a centrally conducted proctored examination as prescribed by the respective platform.

(9) NPTEL/SWAYAM Online Courses: The National Programme on Technology Enhanced Learning (NPTEL)/SWAYAM (Study Webs of Active Learning for Young Aspiring Minds) are the specific Indian platforms to host national Massive Open Online Courses (MOOCs). It offers online courses on a wide range of disciplines to learners anywhere, anytime, to earn university-prescribed credits through proctored examination for the award of a degree. All NPTEL/SWAYAM courses are MOOCs, but not all MOOCs are offered on these specific Indian platforms.

I SEMESTER

ADVANCED ENGINEERING MATHEMATICS			
Course Code	26MPES101	CIE Marks	50
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	50
Total Hours of Pedagogy L /T/P/SL&TW	42:0: 0 :48	Total Marks	100
Credits	03	Exam Hours	03

Course Objective: To develop students' knowledge of linear algebra, vector spaces, matrix decomposition, probability distributions, and random variable transformations for solving engineering problems.

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

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1	Apply direct, iterative, and eigenvalue methods to solve linear equations and matrix problems.	1, 2, 4	-
2	Analyse vector spaces, subspaces, linear independence, basis, and linear transformations.	1, 2, 3	-
3	Apply orthogonalization techniques, QR decomposition, and singular value decomposition to engineering problems.	1, 2, 3, 4	-
4	Analyse probability distributions, random variable transformations, moments, generating functions, and entropy-based measures in engineering applications.	1, 2, 3, 4	-

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

MODULE-1	9 Hrs

Linear Algebra: Solution of Systems of Linear Equations: Direct Methods-Partition method, Croute's Triangularisation method. Iterative method- relaxation method. Eigen values and Eigen vectors. Bounds on Eigen Values. Jacobi method & Givens method for symmetric matrices.

MODULE-2	8 Hrs

Vector Space 1: Introduction to vectors paces and sub-spaces, definitions column, Null spaces. Linearly independent and dependent vectors-Basis definition and problems. Linear transformations definitions. Matrix form of linear Transformations.

MODULE-3	8 Hrs

Vector Space 2: Orthogonal vectors and orthogonal bases. Gram-Schmidt Orthogonalization process. QR decomposition, Singular value decomposition. Applications.

MODULE-4	9 Hrs

Probability distribution functions: Review of basic probability theory. Random variables, Probability distributions: Binomial, Poisson, uniform, and Normal (Gaussian) and Erlang distributions. Joint probability distribution (discrete and continuous). Independent random variables, covariance and correlation.

MODULE-5	8 Hrs

Moments and Transformation of random variables: Moments, Central moments, Transformation of random variables Characteristic functions, probability generating and moment generating functions. Engineering applications: Entropy and Source coding.

Text Books:

1. Linear Algebra and its Applications, David C.Lay etal,Pearson,5th Edition,2015.
2. Numerical Methods for Scientific and Engineering Computation, M.K.Jainetal, New Age International,9th Edition, 2014.
3. Probability and Random Processes, Scott L.Miller, Donald G. Childers. Elsevier2004

Reference Books:

1. Numerical methods for Engineers, Steven Chapra and Raymond P Canale,McGrawHill,7thEdition,2015.
2. Higher Engineering Mathematics, B.S.Grewal, Khanna Publishers,44thEdition,2017
3. Advanced Engineering Mathematics, E.Kreyszig, Wiley,10thedition,2015

Weblinks and Video Lectures(e-Resources):

https://nptel.ac.in/http://nptel.ac.in/courses.php?disciplineId=111http://www.class-central.com/subject/math(MOOCs)http://ocw.mit.edu/courses/mathematics/

Teaching -Learning– Evaluation Scheme:

Sl. No	Teaching and Learning Method	No. of Hours/Week	No. of Weeks	Hours/ Semester
1	Class Room Teaching & Learning	3	14	42
2	Student Study Hours – Self Learning	1	14	14
3	Evaluation of Learning Process	-	-	07
4	Activity Based Learning **(ABL)**	-	-	20+07=27
Total Learning Hours / Semester				**90**

Proposed Assessment Plan (50 marks):

Tool	Remarks	Marks
CIE	Two CIEs conducted for 30 marks each and reduced to 15 marks	30
Activity Details	Details of activities to be conducted Activity 1	10
	Activity 2	10
Total		**50**

Evaluation of Learning Process (07 Hours)

Type of Evaluation	Hours
CIE (1 and 2)	03
Activity (1 and 2)	01
Semester End Exam	03
Total	**07**

MODELLING AND ANALYSIS OF ELECTRICAL MACHINES			
Course Code	26MPES102	CIE Marks	50
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	50
Total Hours of Pedagogy L /T/P/SL&TW	42:0: 0 :48	Total Marks	100
Credits	03	Exam Hours	03

Course Objective: To analyse electrical machine dynamics, reference-frame transformations, and the steady-state and transient performance of DC, induction, and synchronous machines.

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

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1	Model electrical machines using magnetically coupled circuits and electromechanical energy conversion principles.	1, 2, 3, 4	1
2	Develop dynamic and state-space models of DC machines and apply reference-frame transformations to electrical machine equations.	1, 2, 3, 4	1
3	Model and analyse induction machines under steady-state and dynamic operating conditions.	1, 2, 3, 4	1
4	Analyse synchronous machine performance and transient stability using appropriate methods, including the equal-area criterion.	1, 2, 3, 4	1

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

MODULE-1 **9Hrs**

Basic principles for Electrical machine Analysis: Basics of magnetic circuits - flux, mmf, reluctance - self, leakage, magnetizing and mutual inductances**,** Electromechanical energy conversion, machine windings and air gap MMF, winding inductances and voltage equations of electrical machines.

MODULE-2 **8 Hrs**

DIRECT-CURRENT MACHINES: Introduction, Elementary Direct-Current Machine, Voltage and Torque Equations, Dynamic Characteristics of Permanent-Magnet and Shunt DC Motors, Time Domain Block Diagrams and State Equations.

MODULE-3 **8 Hrs**

REFERENCE-FRAME THEORY AND TRANSFORMATIONS: Introduction, Background, Equations of Transformation: Changes of Variables, Stationary Circuit Variables Transformed to the Arbitrary Reference Frame, Commonly Used Reference Frames, Transformation Between Reference Frames, Transformation of a Balanced Set, Balanced Steady-State Phasor Relationships, Balanced Steady-State Voltage Equations, Variables Observed from Several Frames of Reference.

MODULE-4 **8Hrs**

INDUCTION MACHINES: Introduction, Voltage Equations in Machine Variables, Torque Equation in Machine Variables, Equations of Transformation for Rotor Circuits, Voltage Equations in Arbitrary Reference-Frame Variables, Torque Equation in Arbitrary Reference-Frame Variables, Commonly Used Reference Frames, Per Unit System, Analysis of Steady-State Operation, Dynamic Performance During Sudden Changes in Load Torque, Dynamic Performance During a 3-Phase Fault at the Machine Terminals, Modeling in the Arbitrary Reference Frame.

MODULE-5 **9Hrs**

SYNCHRONOUS MACHINES: Introduction, Voltage Equations in Machine Variables, Torque Equation in Machine Variables, Stator Voltage Equations in Arbitrary Reference-Frame Variables, Voltage Equations in Rotor Reference-Frame Variables: Park's Equations, Torque Equations in Substitute Variables, Rotor Angle and Angle Between Rotors, Per Unit System, Analysis of Steady State Operation, Dynamic Performance During a Sudden Change in Input Torque, Dynamic Performance During a 3-Phase Fault at the Machine Terminals, Approximate Transient Torque Versus Rotor Angle Characteristics, First Swing Transient Stability Limit, Critical Clearing Time, Equal-Area Criterion.

Text Books:

Analysis of Electric Machinery and Drive Systems, Paul C Krause, Oleg Wasynczuk, Scott D.Sudhoff, Second Edition, IEEE Press, 2002. (Refer to chapter 1,2,3,4, and 5)

Reference Books:

R. Krishnan, Electric Motor Drives: Modeling, Analysis, and Control, Prentice Hall, 2001.

Reference NPTEL Video Course:

Modelling and Analysis of Electric Machines, IIT Madras, Dr. Krishna Vasudevan.

Teaching -Learning– Evaluation Scheme:

Sl. No	Teaching and Learning Method	No. of Hours/Week	No. of Weeks	Hours/ Semester
1	Class Room Teaching & Learning	3	14	42
2	Student Study Hours – Self Learning	1	14	14
3	Evaluation of Learning Process	-	-	07
4	Activity Based Learning **(ABL)**	-	-	20+07=27
Total Learning Hours / Semester				**90**

Proposed Assessment Plan (50 marks):

Tool	Remarks	Marks
CIE	Two CIEs conducted for 30 marks each and reduced to 15 marks	30
Activity Details	Details of activities to be conducted Activity 1	10
	Activity 2	10
Total		**50**

Evaluation of Learning Process (07 Hours)

Type of Evaluation	Hours
CIE (1 and 2)	03
Activity (1 and 2)	01
Semester End Exam	03
Total	**07**

POWER ELECTRONIC CONVERTERS			
Course Code	26MPES103	CIE Marks	50
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	50
Total Hours of Pedagogy L /T/P/SL&TW	42:0: 0 :48	Total Marks	100
Credits	03	Exam Hours	03

Course Objective: To analyse power electronic converters, their control techniques, and circuit design for electrical engineering applications.

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

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1	Analyse uncontrolled and controlled rectifiers under different load conditions.	1, 2, 3	1
2	Analyse DC–DC converter topologies and their operating characteristics.	1, 2, 3	1
3	Apply single-phase and three-phase inverters using PWM and Space Vector Modulation techniques.	1, 2, 3	1
4	Analyse resonant inverters and converters using ZCS and ZVS techniques.	1, 2, 3	1

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

MODULE-1 — 9 Hrs

Uncontrolled Rectifiers: Introduction, Performance Parameters, Three-Phase Bridge Rectifiers, Three-Phase Bridge Rectifier with RL Load, Three-Phase Rectifier with a Highly Inductive Load, Comparisons of Diode Rectifiers.

Controlled Rectifiers: Introduction, Single-Phase Full Converters, Single-Phase Full Converter with RL Load. Three-Phase Full Converters, Three-Phase Full Converter with RL Load. Pulse Width-Modulation Control: PWM Control, Single-Phase Sinusoidal PWM, Three-Phase PWM Rectifier. Twelve-Pulse Converters, Design of Converter Circuits, Effects of Load and Source Inductances.

MODULE-2 — 9 Hrs

DC–DC Converters: Introduction, Performance Parameters of DC–DC Converters, Principle of Step-Down Operation, Generation of Duty Cycle, Step-Down Converter with RL Load, Principle of Step-Up Operation, Step-Up Converter with a Resistive Load, Frequency Limiting Parameters, Converter Classification, Switching-Mode Regulators: Buck Regulators, Boost Regulators, Buck Boost Regulators, Cúk Regulators, Limitations of Single-Stage Conversion, Comparison of Regulators. [Power electronics devices, circuits, and applications.

MODULE-3 — 8 Hrs

DC–AC Converters (Inverters): Introduction, Performance Parameters, Principle of Operation, Single-Phase Bridge Inverters, Three-Phase Inverters, 180-Degree Conduction, 120-Degree Conduction, Voltage Control of Single-Phase Inverters: Multiple-Pulse-Width Modulation, Sinusoidal Pulse-Width Modulation, Modified Sinusoidal Pulse-Width Modulation, Phase Displacement Control.

MODULE-4 — 8 Hrs

DC–AC Converters (Continued): Voltage Control of Three-Phase Inverters, Sinusoidal PWM, 60 Degree PWM, Third-Harmonic PWM, Space Vector Modulation, Comparison of PWM Techniques, Harmonic Reductions, Current-Source Inverters, Variable DC-Link Inverter, Boost Inverter, Inverter Circuit Design.

MODULE-5 — 8 Hrs

Resonant Pulse Inverters: Introduction, Series Resonant Inverters, Series Resonant Inverters with Unidirectional Switches, Parallel Resonant Inverters, Voltage Control of Resonant Inverters, Class E Resonant Inverter, Class E Resonant Rectifier, Zero-Current-Switching Resonant Converters: L-Type ZCS Resonant Converter, M-Type ZCS Resonant Converter. Zero-Voltage-Switching Resonant Converters, Comparisons Between ZCS and ZVS Resonant Converters.

Text Books:

Power Electronics Devices, Circuits, and Applications Fourth Edition, Muhammad H. Rashid, Pearson. (Refer to chapters 3,10,5,6, and 7)

Reference Books:

1. Power Electronics: Converters, Applications, and Design, Ned Mohan, 3rd Edition, John Wiley & Sons.
2. Fundamentals of Power Electronics, Robert W. Erickson, 2nd Edition, Springer.
3. Power Electronics: Essentials and Applications, L. Umanand, Wiley India.

Teaching -Learning– Evaluation Scheme:

Sl. No	Teaching and Learning Method	No. of Hours/Week	No. of Weeks	Hours/ Semester
1	Class Room Teaching & Learning	3	14	42
2	Student Study Hours – Self Learning	1	14	14
3	Evaluation of Learning Process	-	-	07
4	Activity Based Learning **(ABL)**	-	-	20+07=27
Total Learning Hours / Semester				**90**

Proposed Assessment Plan (50 marks):

Tool	Remarks	Marks
CIE	Two CIEs conducted for 30 marks each and reduced to 15 marks	30
Activity Details	Details of activities to be conducted Activity 1	10
	Activity 2	10
Total		**50**

Evaluation of Learning Process (07 Hours)

Type of Evaluation	Hours
CIE (1 and 2)	03
Activity (1 and 2)	01
Semester End Exam	03
Total	**07**

POWER SYSTEMS OPERATION, STABILITY, PROTECTION AND POWER QUALITY			
Course Code	26MPES104	CIE Marks	50
Teaching Hours/Week (L:T:P)	4:0:0	SEE Marks	50
Total Hours of Pedagogy L /T/P/SL&TW	56:0: 0 :64	Total Marks	100
Credits	04	Exam Hours	03

Course Objective: To analyse power system control, protection, reactive power compensation, transmission transients, and power quality.

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

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1	Analyse generator voltage, frequency control, and power-system stabiliser operation.	1, 2, 3	1
2	Analyse reactive-power compensation and protection techniques in power systems.	1, 2, 3	1
3	Analyse travelling waves, transient overvoltages, and insulation coordination in transmission systems.	1, 2, 3	1
4	Evaluate power-quality disturbances and applicable standards in power systems.	1, 2, 3	1

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

MODULE-1 — 12 Hrs

Power System Controls: Generator-Voltage Control, Turbine-Governor Control, Load-Frequency Control, Power System Stabilizer Control.

Load Compensation and Reactive Power Characteristics: Introduction: The Requirement for Compensation, Objectives in Load Compensation, The Ideal Compensator: Practical Considerations, Loads Requiring Compensation, Acceptance Standards for the Quality of Supply, Specification of a Load Compensator. Power Factor and Its Correction, Voltage Regulation, Approximate Reactive Power Characteristics, Voltage Regulation with a Varying Inductive Load, Power Factor Improvement, Reactive Power Bias, Load Compensator as a Voltage Regulator.

MODULE-2 — 10 Hrs

Steady-State Reactive Power Control in Electric Transmission Systems: Introduction Uncompensated Transmission Lines: Electrical Parameters, Fundamental Transmission Line Equation, Surge Impedance and Natural Loading, The Uncompensated Line on Open-Circuit, The Uncompensated Line Under Load: Effect of Line Length, Load Power, and Power Factor on Voltage and Reactive Power, The Uncompensated Line Under Load: Maximum Power and Stability Considerations. Compensated Transmission Lines, Passive and Active Compensators.

MODULE-3 — 10 Hrs

Power System Protection: System Protection Components, Instrument Transformers, Overcurrent Relays, Radial System Protection, Reclosers, Fuses, and Sectionalizers, Directional Relays, Protection of a Two-Source System with Directional Relays, Zones of Protection, Line Protection with Impedance (Distance)Relays, Differential Relays, Bus Protection with Differential Relays, Transformer Protection with Differential Relays, Pilot Relaying, Numeric Relaying.

MODULE-4 — 12 Hrs

Transmission lines transient operation: Traveling Waves on Single-Phase Lossless Lines, Boundary Conditions for Single-Phase Lossless Lines, Bewley Lattice Diagram, Discrete-Time Models of Single-Phase Lossless Lines and Lumped RLC Elements, Lossy Lines, Multiconductor Lines, Power System Over voltages, Insulation Coordination.

MODULE-5 — 12 Hrs

Introduction to power quality: Definition of power quality, Causes of disturbances in power systems, Classification of power quality issues, Formulations and measures used for power quality, Effects of poor power quality on power system devices, Standards and guidelines referring to power quality.

Text Books:

1. Power System Analysis and Design, J. Duncan Glover, et. Al. Seventh Edition, 2022 Cengage Learning. (Refer to chapters 13, 11, and 14)
2. Reactive Power Control in Electric Systems, T. J. E. Miller, John Wiley & Sons, 1982. (Refer to chapters 1 and 2)
3. Power Quality in Power Systems, Electrical Machines, and Power-Electronic Drives, Ewald F. Fuchs and Mohammad A. S. Masoum, Third Edition, 2023. (Refer to chapter 1)

Reference Books:

1. Power System Stability and Control, Prabha Kundur, McGraw-Hill, 1994.
2. Power System Control and Stability, P. M. Anderson and A. A. Fouad, 2nd Edition, Wiley-IEEE Press, 2003.
3. Roger C. Dugan, Mark F. McGranaghan, Surya Santoso and H. Wayne Beaty, Electrical Power Systems Quality, 3rd Edition, McGraw-Hill, 2012.

Teaching -Learning– Evaluation Scheme:

Sl. No	Teaching and Learning Method	No. of Hours/Week	No. of Weeks	Hours/ Semester
1	Class Room Teaching & Learning	4	14	56
2	Student Study Hours – Self Learning	1	14	14
3	Evaluation of Learning Process	-	-	07
4	Activity Based Learning **(ABL)**	-	-	22+21=43
Total Learning Hours / Semester				**120**

Proposed Assessment Plan (50 marks):

Tool	Remarks	Marks
CIE	Two CIEs conducted for 30 marks each and reduced to 15 marks	30
Activity Details	Details of activities to be conducted Activity 1	10
	Activity 2	10
Total		**50**

Evaluation of Learning Process (07 Hours)

Type of Evaluation	Hours
CIE (1 and 2)	03
Activity (1 and 2)	01
Semester End Exam	03
Total	**07**

INTELLIGENT EMBEDDED SYSTEMS FOR RENEWABLE ENERGY SYSTEMS			
Course Code	26MPES105	CIE Marks	50
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	50
Total Hours of Pedagogy L /T/P/SL&TW	42:0: 0 :48	Total Marks	100
Credits	03	Exam Hours	03

Course Objective: To develop skills in soft computing, embedded systems, and intelligent monitoring of solar energy systems.

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

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1	Explain PV system characteristics and MPPT techniques.	1, 2, 3	1, 2
2	Utilize AI and soft computing methods for PV system performance improvement.	1, 2, 3	1, 2
3	Implement embedded and IoT-based PV monitoring and data acquisition.	1, 2, 3	1, 2
4	Evaluate solar forecasting models and embedded climatic monitoring applications.	1, 2, 3	1, 2

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

MODULE-1	9 Hrs

Solar Photovoltaic Systems and Embedded MPPT Control: Solar photovoltaic (PV) system fundamentals, PV cell and module characteristics, I–V and P–V characteristics, single-diode and double-diode equivalent circuits, effect of solar irradiance and temperature, maximum power point (MPP), partial shading conditions, DC–DC converters, MPPT control algorithms: Constant Voltage, Perturb and Observe (P&O), Incremental Conductance (IC), Fuzzy Logic Controller, Artificial Neural Network (ANN), and Differential Evolution.

MODULE-2	8 Hrs

Artificial Intelligence and Soft Computing for Solar PV Systems: Introduction to Artificial Intelligence (AI) in PV systems, challenges in PV system performance and control, ensemble learning, machine learning, deep learning, Convolutional Neural Networks (CNN), Boltzmann Machines, Autoencoders, Extreme Learning Machine (ELM), neural network-based techniques, metaheuristic-based AI techniques, AI applications in PV system optimization, fault detection, performance assessment, and control.

MODULE-3	9 Hrs

Embedded Systems and IoT-Based Solar PV Monitoring: IoT-based solar PV monitoring systems, hardware architecture of data acquisition systems (DAS), sensors for voltage, current, temperature, humidity, and solar irradiance measurement, microcontroller-based data acquisition, sensor interfacing, data acquisition and processing, real-time PV system monitoring, wired and wireless communication, IoT integration, remote monitoring of solar PV systems, performance evaluation and validation of monitoring systems, and IoT-integrated marine photovoltaic systems.

MODULE-4	8 Hrs

Solar Energy Forecasting using Deep Learning: Fundamentals of solar energy forecasting, solar irradiance and PV power prediction, forecasting techniques, Moving Average, ARIMA, SARIMA, K-Nearest Neighbors (KNN), Regression Trees, Long Short-Term Memory (LSTM) networks, deep learning-based solar energy forecasting, data preprocessing, temporal weather data analysis, data mining and visualization, cross-validation, forecasting performance evaluation using error metrics, and comparison of forecasting models.

MODULE-5	8 Hrs

Embedded Systems for Solar Energy and Climatic Parameter Monitoring: Solar-powered embedded systems, embedded system architecture for climatic parameter measurement, analog and digital sensors, microcontroller-based monitoring systems, measurement of solar irradiance, ambient temperature, humidity, voltage, and current, solar-powered data acquisition systems, sensor interfacing, data logging, wired and wireless data transmission, embedded system applications in environmental monitoring, performance monitoring of solar PV systems, and solar-powered automated temperature control systems.

Text Books:

Applied soft computing and embedded system applications in solar energy, Rupendra Kumar Pachauri, CRC Press, 2021. (Refer to chapters 1, 4, 7,8,9,10)

Reference Books:

1. Introduction to Embedded Systems, Shibu K. V., 2nd Edition, McGraw-Hill Education, 2017.
2. AI and IoT in Renewable Energy, Rabindra Nath Shaw, Springer, 2021.
3. Embedded Systems: SoC, IoT, AI and Real-Time Systems, Raj Kamal,4th Edition, McGraw Hill Education, 2020.

Teaching -Learning– Evaluation Scheme:

Sl. No	Teaching and Learning Method	No. of Hours/Week	No. of Weeks	Hours/ Semester
1	Class Room Teaching & Learning	3	14	42
2	Student Study Hours – Self Learning	1	14	14
3	Evaluation of Learning Process	-	-	07
4	Activity Based Learning **(ABL)**	-	-	20+07=27
Total Learning Hours / Semester				**90**

Proposed Assessment Plan (50 marks):

Tool	Remarks	Marks
CIE	Two CIEs conducted for 30 marks each and reduced to 15 marks	30
Activity Details	Details of activities to be conducted Activity 1	10
	Activity 2	10
Total		**50**

Evaluation of Learning Process (07 Hours)

Type of Evaluation	Hours
CIE (1 and 2)	03
Activity (1 and 2)	01
Semester End Exam	03
Total	**07**

PROFESSIONAL ELECTIVE COURSE-I

RENEWABLE ENERGY SYSTEMS AND GRID INTEGRATION			
Course Code	26MPES1061	CIE Marks	50
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	50
Total Hours of Pedagogy L /T/P/SL&TW	42:0: 0 :48	Total Marks	100
Credits	03	Exam Hours	03

Course Objective: To analyse solar and wind energy systems, energy storage, power converters, and grid integration of renewable energy sources.

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

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1	Analyse photovoltaic cells, arrays, and solar power conversion systems.	1, 2, 3	1, 2
2	Analyse wind energy conversion systems, maximum power extraction, and generator technologies.	1, 2, 3	1, 2
3	Evaluate battery energy storage systems, charging methods, and power electronic interfaces.	1, 2, 3	1, 2
4	Analyse grid integration of renewable energy systems with respect to stability, voltage regulation, harmonics, and power quality.	1, 2, 3	1, 2

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

MODULE-1 **9 Hrs**

Photovoltaic Power: Building-Integrated PV System, PV Cell Technologies.

Photovoltaic Power Systems: PV Cell, Module and Array, Equivalent Electrical Circuit, Open Circuit Voltage and Short-Circuit Current, I-V and P-V Curves, Array Design, Peak-Power Operation, System Components of Stand-Alone System.

MODULE-2 **8 Hrs**

Solar Power Conversion Systems and Grid-Connected PV: Solar Power Conversion Systems: Overview, Solar power Electronics systems, Challenges.

Power Electronics: AC-DC Rectifiers, AC-DC Inverter, IGBT/MOSFET Based Converter, Control Schemes, Cycloconverter, Grid Interface Controls, Battery Charge/Discharge Converters, Power Shunts.

MODULE-3 **9 Hrs**

Wind Speed and Energy: Speed and Power Relation, Power Extracted from the Wind, Rotor-Swept Area, Air Density, Wind Speed Distribution, Wind Speed Prediction.

Wind Power Systems: System Components, Turbine Rating, Power vs. Speed and TSR, Maximum Energy Capture, Maximum Power Operation, System-Design Trade-offs, System Control Requirements.

Electrical Generators: Turbine conversion systems, Synchronous Generator, Induction Generator, Doubly Fed Induction Generator, Direct-Driven Generator.

MODULE-4 **8 Hrs**

Energy Storage and Power Electronic Interfaces: Energy Storage, Battery, Types of Battery, Equivalent Electrical Circuit, Performance Characteristics, Lead-Acid Battery, Battery Design, Battery Charging, Charge Regulators, Battery Management, More on Lithium-Ion Batteries.

Power Electronics: Battery Charge/Discharge Converters.

MODULE-5 **8 Hrs**

Grid-Connected Renewable Energy Systems and Electrical Performance: Stand-Alone Systems, PV Stand-Alone, Wind Stand-Alone, Hybrid Systems, System Sizing.

Grid-Connected Systems: Interface Requirements, Synchronizing with the Grid, Operating Limit, Energy Storage and Load Scheduling, Wind Farm–Grid Integration, Grid Stability Issues, Distributed Power Generation.

Electrical Performance: Voltage Current and Power Relations, Component Design for Maximum Efficiency, Electrical System Model, Static Bus Impedance and Voltage Regulation, Dynamic Bus Impedance and Ripples, Harmonics, Quality of Power, Renewable Capacity Limit.

Text Books:

Wind and Solar Power Systems: Design, Analysis, and Operation, Mukund R. Patel and Omid Beik, 3rd Edition, CRC Press, 2021. (Refer to chapters 10,11,12,14,3,4,5,13,15,16, and17)

Reference Books:

Nick Jenkins and Janaka Ekanayake, Renewable Energy Engineering, 2nd Edition, Cambridge University Press, 2024.

Teaching -Learning– Evaluation Scheme:

Sl. No	Teaching and Learning Method	No. of Hours/Week	No. of Weeks	Hours/ Semester
1	Class Room Teaching & Learning	3	14	42
2	Student Study Hours – Self Learning	1	14	14
3	Evaluation of Learning Process	-	-	07
4	Activity Based Learning **(ABL)**	-	-	20+07=27
Total Learning Hours / Semester				**90**

Proposed Assessment Plan (50 marks):

Tool	Remarks	Marks
CIE	Two CIEs conducted for 30 marks each and reduced to 15 marks	30
Activity Details	Details of activities to be conducted Activity 1	10
	Activity 2	10
Total		**50**

Evaluation of Learning Process (07 Hours)

Type of Evaluation	Hours
CIE (1 and 2)	03
Activity (1 and 2)	01
Semester End Exam	03
Total	**07**

ENERGY STORGAE IN POWER GRIDS			
Course Code	26MPES1062	CIE Marks	50
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	50
Total Hours of Pedagogy L /T/P/SL&TW	42:0: 0 :48	Total Marks	100
Credits	03	Exam Hours	03

Course Objective: To understand electrical energy storage technologies, their applications in power systems and fuzzy logic-based energy management of hybrid renewable energy systems.

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

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1	Explain the need, characteristics and different technologies of electrical energy storage.	1, 12	-
2	Analyze the applications and benefits of energy storage in power system operation.	1, 6	-
3	Apply fuzzy logic for managing kinetic energy storage in hybrid wind-diesel systems.	1, 6	-
4	Analyze supervisory control strategies for hybrid wind power and multisource energy storage systems.	1, 6	-

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

MODULE-1 — 9 Hrs

Electrical Energy Storage: Difficulties of storing electrical energy, Need for storing electrical energy, Value enhancement of storage in electrical grids, Storage management.

Recent Developments in Energy Storage: Introduction, Storage technologies, Characteristics of a storage system, Hydraulic storage, Compressed-air storage, Thermal storage, Chemical storage, Kinetic storage, Electrostatic storage, Electromagnetic storage.

MODULE-2 — 8 Hrs

Applications and Values of Energy Storage in Power Systems: Introduction, Introduction to power systems and their operation, Services that can be provided by storage, Example of the contribution of storage to the treatment of congestion events and dynamic support of frequency control in an island grid

MODULE-3 — 9 Hrs

Introduction to Fuzzy Logic and Application to the Management of Kinetic Energy Storage in a Hybrid Wind-Diesel System: Introduction, Introduction to fuzzy logic, Wind-kinetic energy storage combination on an isolated site with a diesel generator.

MODULE-4 — 8 Hrs

Supervisor Construction Methodology for a Wind power Source Combined with Storage: Introduction, Energetic system studied, Supervisor development methodology, Specifications, Supervisor structure, Identification of various operating states: functional graph, Membership functions, Operational graph, Fuzzy rules.

MODULE-5 — 8 Hrs

Design of a Hybrid Multisource/Multistorage Supervisor: Introduction, Methodology for the construction of a supervisor for a hybrid source incorporating wind power, Compared performance of different variants of hybrid source.

Text books:

1. Energy Storage in Electric Power Grids, Benoît Robyns et al, Wiley, 2015.

Teaching -Learning– Evaluation Scheme:

Sl. No	Teaching and Learning Method	No. of Hours/Week	No. of Weeks	Hours/ Semester
1	Class Room Teaching & Learning	3	14	42
2	Student Study Hours – Self Learning	1	14	14
3	Evaluation of Learning Process	-	-	07
4	Activity Based Learning **(ABL)**	-	-	20+07=27
Total Learning Hours / Semester				**90**

Proposed Assessment Plan (50 marks):

Tool	Remarks	Marks
CIE	Two CIEs conducted for 30 marks each and reduced to 15 marks	30
Activity Details	Details of activities to be conducted Activity 1	10
	Activity 2	10
Total		**50**

Evaluation of Learning Process (07 Hours)

Type of Evaluation	Hours
CIE (1 and 2)	03
Activity (1 and 2)	01
Semester End Exam	03
Total	**07**

GAS INSULATED SYSTEMS			
Course Code	26MPES1063	CIE Marks	50
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	50
Total Hours of Pedagogy L /T/P/SL&TW	42:0: 0 :48	Total Marks	100
Credits	03	Exam Hours	03

Course Objective: To understand the properties, design, construction, operation and diagnostic techniques of Gas Insulated Substations (GIS).

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

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1	Explain SF_6 properties, handling and safety aspects in GIS.	1, 2	1, 2
2	Explain GIS layout, planning, installation and economic aspects.	1, 2, 3	1, 2
3	Analyze GIS design, insulation coordination and thermal considerations.	1, 2, 3	1, 2
4	Analyze VFTO phenomena, insulation problems and GIS diagnostic techniques.	1, 2, 3	1, 2

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

MODULE-1 **9 Hrs**

INTRODUCTION TO GIS AND PROPERTIES OF SF6 Characteristics of GIS- Introduction to SF6 - Physical properties-Chemical properties - Electrical properties-Specification of SF6 gas for GIS application - Handling of SF6 gas before use - Safe handling of SF6 gas in electrical equipment - Equipment for handling the SF6 Gas - SF6 and environment.

MODULE-2 **8 Hrs**

LAYOUT OF GIS STATIONS: Advancement of GIS station - Comparison with Air Insulated Substation - Economics of GIS - User Requirements for GIS - Main Features for GIS - Planning and Installation components of a GIS station.

MODULE-3 **9 Hrs**

DESIGN AND CONSTRUCTION OF GIS STATION Introduction - Rating of GIS components - Design Features - Estimation of different types of Electrical Stresses -Design Aspects of GIS components - Insulation Design for Components - Insulation Design for GIS - Thermal Considerations in the Design of GIS - Effect of very Fast Transient Over-voltages (VFTO) on the GIS design - Insulation Coordination systems - Gas handling and Monitoring System Design.

MODULE-4 **8 Hrs**

FAST TRANSIENT PHENOMENA IN GIS Introduction - Disconnector Switching in Relation to Very fast Transients-Origin of VFTO-Propagation and Mechanism of VFTO-VFTO Characteristics- Effects of VFTO-Testing of GIS for VFTO.

MODULE-5 **8 Hrs**

SPECIAL PROBLEMS IN GIS AND GIS DIAGNOSTICS Introduction - particles their effects and their control- Insulating Spacers and their Reliability - SF6 Gas Decomposition - Characteristics of imperfections in insulation - Insulation Diagnostic methods - PD Measurement and UHF Method.

Text Books:

1. M. S. Naidu," Gas Insulated Substations"- IK International Publishing House.
2. Hermann J. Koch, "Gas Insulated Substations", June 2014, Wiley - IEEE Press.

Reference Books:

1. Olivier Gallot-Lavellee, "Dielectric materials and Electrostatics" , Wiley - IEEE Press.
2. Jaun Martinez, "Dielectric Materials for Electrical Engineering", Wiley - IEEE Press.

Teaching -Learning– Evaluation Scheme:

Sl. No	Teaching and Learning Method	No. of Hours/Week	No. of Weeks	Hours/ Semester
1	Class Room Teaching & Learning	3	14	42
2	Student Study Hours – Self Learning	1	14	14
3	Evaluation of Learning Process	-	-	07
4	Activity Based Learning **(ABL)**	-	-	20+07=27
Total Learning Hours / Semester				**90**

Proposed Assessment Plan (50 marks):

Tool	Remarks	Marks
CIE	Two CIEs conducted for 30 marks each and reduced to 15 marks	30
Activity Details	Details of activities to be conducted Activity 1	10
	Activity 2	10
Total		**50**

Evaluation of Learning Process (07 Hours)

Type of Evaluation	Hours
CIE (1 and 2)	03
Activity (1 and 2)	01
Semester End Exam	03
Total	**07**

HYDROGEN FUEL CELLS			
Course Code	26MPES1064	CIE Marks	50
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	50
Total Hours of Pedagogy L /T/P/SL&TW	42:0: 0 :48	Total Marks	100
Credits	03	Exam Hours	03

Course Objective: To understand hydrogen energy systems, hydrogen production, storage and transportation methods, fuel cell technologies and their applications.

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

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1	Explain the hydrogen energy economy, its current status and applications.	1, 2, 3	1, 2
2	Describe the properties of hydrogen and various hydrogen production techniques.	1, 2, 3	1, 2
3	Compare different hydrogen storage and transportation methods.	1, 2, 3	1, 2
4	Analyze fuel cell technologies, their performance and applications in energy systems.	1, 2, 3	1, 2

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

MODULE-1	8 Hrs

Hydrogen Energy Economy: Hydrogen Energy Economy – Conception, Present status and a vision – Applications of Hydrogen - Transport application-cars, light trucks, buses - Stationary and Portable Electronic gadgets.

MODULE-2	8 Hrs

Hydrogen and Production Techniques: Hydrogen – Physical and chemical properties, salient characteristics - Production of hydrogen – Steam reforming – Water electrolysis – Gasification and woody biomass conversion – Biological hydrogen production – Photo dissociation – Direct thermal or catalytic splitting of water.

MODULE-3	9 Hrs

Hydrogen Storage & Transport: Hydrogen storage options – Compressed gas – Liquid hydrogen – Hydride – Chemical Storage – Comparisons - Transport of Hydrogen - Pipelines, gaseous, liquid and compound materials.

MODULE-4	9 Hrs

Fuel Cells: History – Principle - Working - Thermodynamics and kinetics of fuel cell process – Types of fuel cells – AFC, PAFC, SOFC, MCFC, DMFC, PEMFC – Relative merits and demerits - Performance evaluation of fuel cell – Comparison of battery Vs fuel cell – Flow Battery.

MODULE-5	8 Hrs

Application of Fuel Cell: Fuel cell usage for domestic power systems - Large scale power generation – Automobile - Space - Environmental analysis of usage of Hydrogen in Fuel cell - Future trends in fuel cells.

Text Books:

1. Hydrogen and Fuel Cells: A Comprehensive Guide, Rebecca L. and Busby, Penn Well Corporation, Oklahoma (2005).
2. Fuel Cells – Principles and Applications, Viswanathan, B and M Aulice Scibioh, Universities Press (2006).

Reference Books:

1. Hydrogen and Fuel Cells: A Comprehensive Guide, Rebecca L. and Busby, Penn Well Corporation, Oklahoma (2005) .
2. Hydrogen and Fuel Cells: Emerging Technologies and Applications, Bent Sorensen (Sørensen), Elsevier, UK (2005) .
3. Fuel Cell and Their Applications, Kordesch, K and G.Simader, Wiley-Vch, Germany (1996).
4. Fuel Cells: Theory and Application, Hart, A.B and G.J.Womack, Prentice Hall, NewYork Ltd., London (1989). 5. The Hydrogen Economy, Jeremy Rifkin, Penguin Group, USA (2002).
5. Fuel Cells – Principles and Applications, Viswanathan, B and M Aulice Scibioh, Universities Press (2006).
6. Online lecture on Hydrogen Economy, https://www.youtube.com/watch?v=-yYrc1-thxQ

Teaching -Learning– Evaluation Scheme:

Sl. No	Teaching and Learning Method	No. of Hours/Week	No. of Weeks	Hours/ Semester
1	Class Room Teaching & Learning	3	14	42
2	Student Study Hours – Self Learning	1	14	14
3	Evaluation of Learning Process	-	-	07
4	Activity Based Learning **(ABL)**	-	-	20+07=27
Total Learning Hours / Semester				**90**

Proposed Assessment Plan (50 marks):

Tool	Remarks	Marks
CIE	Two CIEs conducted for 30 marks each and reduced to 15 marks	30
Activity Details	Details of activities to be conducted Activity 1	10
	Activity 2	10
Total		**50**

Evaluation of Learning Process (07 Hours)

Type of Evaluation	Hours
CIE (1 and 2)	03
Activity (1 and 2)	01
Semester End Exam	03
Total	**07**

ENERGY LABORATORY			
Course Code	26MPESL107	CIE Marks	50
Teaching Hours/Week (L:T:P)	0:0:2	SEE Marks	50
Total Hours of Pedagogy L:T:P:SL:TW	0:0:28:2	Total Marks	100
Credits	01	Exam Hours	03

Course Objective: To practice analysis of modeling of renewable energy systems using MATLAB simulation.

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

#	Course Outcomes	Mapping to POs	Mapping to PSOs
1	Demonstrate the characteristics and performance of PV modules.	1, 9, 10, 11	2
2	Analyze grid connected renewable energy system using simulation tool	1, 5, 9, 10, 11	2
3	Design solar PV systems using MATLAB	1, 5, 9, 10, 11	2

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

LIST OF EXPERIMENTS

1. Characteristics of solar PV cell/modules.
2. Performance of PV cell/ module under partial shading conditions.
3. Simulation study on Solar PV Energy System
4. Simulation of Buck, Boost converters, resonant converters systems
5. Simulation of a grid-connected solar PV system incorporating Maximum Power Point Tracking (MPPT) using MATLAB/Simulink. Plot the Power versus Voltage) and Current–versus Voltage characteristics of the PV array under MPPT operation.
6. MATLAB /Simulink modelling of solar PV Fed induction motor/BLDC motor
7. MATLAB /Simulink modelling of partial shading effects on solar PV array
8. Simulation study on Wind Energy Generator
9. Simulation study on Hybrid (Solar-Wind) Power System
10. Emulation on Integrated renewable energy system for on/off grid applications using software tools (HOMER)
11. Simulation related energy audit and demand side management using software tools (HOMER)

Scheme of Evaluation

Component	Description	Marks
Allotment of marks for regular classwork		
Ability in Conducting Experiments	Initiative, skill, safety practices, teamwork, and independent handling of equipment during regular lab sessions.	10
Laboratory Record / Journal	Regular and neat maintenance of lab record, accuracy of results, and timely submission.	20
	Subtotal	30
Allotment of marks for CIE practical test		
Laboratory Test / Experiment Performance	Ability to set up apparatus, follow procedure, take observations, and obtain correct results in the test experiment.	10
Viva-Voce	Understanding of theory, concepts, and experimental procedure; ability to explain results and answer related questions.	10
	Subtotal	20
	CIE Total	**50**
	SEE	**50**
	CIE + SEE Total	**100**