Punyashlok Ahilyadevi Holkar Solapur University, Solapur

पुण्यश्लोक अहिल्यादेवी होळकर सोलापूर विद्यापीठ

॥ विद्यया संपन्नता ॥

Name of the Faculty: Science & Technology

CHOICE BASED CREDIT SYSTEM

Subject: Electrical Engineering

Name of the Course: Final Year B. Tech

(Syllabus to be implemented from w. e. f. June 2026)

Punyashlok Ahilyadevi Holkar Solapur University,
Solapur Faculty of Engineering & Technology
B. Tech (Electrical Engineering)

PROGRAMME: BACHELOR OF ELECTRICAL ENGINEERING

PROGRAMME OBJECTIVES

A. PROGRAM EDUCATIONAL OBJECTIVES

1. Deliver fundamental as well as advanced knowledge with research initiatives in the field of electrical engineering with emphasis on state-of-the-art technology.
2. Graduates will demonstrate measurable progress in the fields they choose to pursue.
3. Design and develop technically feasible solutions for real-world applications that are economically viable, leading to societal benefits.
4. To nurture Graduates to be sensitive to ethical, societal, and environmental issues while conducting their professional work.

B. PROGRAMME OUTCOMES

Students attain the following outcomes: -

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 public health and safety, and cultural, societal, and environmental considerations.

4 **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5 **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to complex engineering activities with an understanding of the limitations.

6 **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

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

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

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

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

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

12 **Lifelong learning:** Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change.

C. PROGRAMME SPECIFIC OUTCOMES

1 An ability to specify, design, and analyze Power Systems, Electrical Machinery, Electronic Circuits, Drive Systems, Lightning Systems delivers technological solutions by adapting advances in allied disciplines.

2 Apply knowledge of electrical engineering to meet the desired needs within realistic constraints, viz., economical, ethical, environmental, and safety.

3 Apply modern software tools for the design, simulation, and analysis of electrical systems to successfully adapt to multi-disciplinary environments.

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॥ विद्यया संपन्नता ॥
NAAC Accredited-2022 'B++' Grade (CGPA-2.96)

PUNYASHLOK AHILYADEVI HOLKAR SOLAPUR UNIVERSITY, SOLAPUR

FACULTY OF SCIENCE & TECHNOLOGY

NEP 2020 Compliant Curriculum

With effect from 2023-2024

Semester I (Common for All Engineering Branches)

Course Type	*Course Code*	*Name of the Course*	*Engagement Hours*		*Credits*	*FA*	*SA*		*Total*
			L	*P*		*ESE*	*ISE*	*ICA*	
BSC	BS-01/ BS-02	Engineering Physics / Engineering Chemistry $	3	2	4	70	30	25	125
	BS-03	Engineering Mathematics-I	3	2	4	70	30	25	125
ESC	ES-01/ ES-02	Basics of Civil and Mechanical Engineering /Basic Electrical & Electronics Engineering $	3	2	4	70	30	25	125
	ES-03	Engineering Mechanics	3	2	4	70	30	25	125
AEC	AE-01	Communication Skills	1	2	2		25	25	50
CC	CC-01	Sports and Yoga or NSS/NCC/UBA (Liberal Learning Course-I)	1	2	2			25	25
SEC	SE-01	Workshop Practices		2	1			25	25
		Total	**14**	**14**	**21**	**280**	**145**	**175**	**600**
		Student Induction Program**							

Semester II (Common for All Engineering Branches)

Course Type	*Course Code*	*Name of the Course*	*Engagement Hours*		*Credits*	*FA*	*SA*		*Total*
			L	*P*		*ESE*	*ISE*	*ICA*	
BSC	BS-01/ BS-02	Engineering Physics / Engineering Chemistry $	3	2	4	70	30	25	125
	BS-04	Engineering Mathematics – II	3	2	4	70	30	25	125
ESC	ES-01/ ES-02	Basics of Civil and Mechanical Engineering / Basic Electrical & Electronics Engineering $	3	2	4	70	30	25	125
		Engineering Graphics and CAD		4	2		25	50	75
SEC	SE-02	Data Analysis and Programming Skills	1	2	2		25	25	50
CC	CC-02	Professional Personality Development (Liberal Learning Course-II)	1	2	2		25	25	50
IKS	IKS-01	Introduction to Indian Knowledge System	2		2		25	25*	50
		Total	**13**	**14**	**20**	**210**	**190**	**200**	**600**
		Democracy, Elections and Good Governance *	**1**			**50**			

***For IKS activity report should be submitted**

BSC- Basic Science Course, ESC- Engineering Science Course, PCC- Programme Core Course,

AEC- Ability Enhancement Course, IKS- Indian Knowledge System, CC- Co-curricular Courses ,

VSEC-Vocational and Skill Enhancement Course

- Legends used–

L	Lecture	FA	Formative Assessment
T	Tutorial	SA	Summative Assessment
P	Lab Session	ESE	End Semester Examination
		ISE	In Semester Evaluation
		ICA	Internal Continuous Assessment

- **Notes-**

1. $ - Indicates approximately half of the total students at F. Y. will enroll under Group A and the remaining will enroll under Group B.

   Group A will take up the course of Engineering Physics (theory & laboratory) in Semester I and will take up the course of Engineering Chemistry (theory & laboratory) in Semester II.

   Group B will take up the course of Engineering Chemistry (theory & laboratory) in Semester I and will take up the course of Engineering Physics (theory & laboratory) in Semester II.

2. # - For the Course (C113) Basic Electrical & Electronics Engineering, Practicals of Basic Electrical Engineering and Basic Electronics Engineering will be conducted in alternate weeks.

3. @ - For the Course (C113) Basics of Civil and Mechanical Engineering, Practicals of Basics of Civil Engineering and Basics of Mechanical Engineering will be conducted in alternate weeks.

4. In Semester Evaluation (ISE) marks shall be based upon the student's performance in a minimum of two tests & mid-term written test conducted & evaluated at the institute level.

   Internal Continuous Assessment Marks (ICA) are calculated based on student's performance during laboratory sessions/tutorial sessions.

5. *- Democracy, Elections & Good Governance is a mandatory course. The marks earned by students in this course shall not be considered for the calculation of SGPA/CGPA. However, the student must complete the End Semester Examination (ESE) of 50 marks (as prescribed by the university) for fulfillment of this course. This course is not considered a passing head for counting passing heads for ATKT. However, students must pass this subject for the award of the degree.
6. Students must complete an induction program of a minimum of five days before the commencement of the regular academic schedule in the first semester.

** GUIDELINES FOR INDUCTION PROGRAM (C119)

New entrants into an Engineering program come with diverse thoughts, mindsets, and different social, economic, regional, and cultural backgrounds. It is important to help them adjust to the new environment and inculcate in them the ethos of the institution with a sense of larger purpose.

An induction program for the new UG entrant students is proposed at the commencement of the first semester. It is expected to complete this induction program before the commencement of the regular academic schedule.
Its purpose is to make new entrants comfortable in their new environment, open them up, set a healthy daily routine for them, create bonding amongst their peers as well as between faculty and students, develop awareness, sensitivity, and understanding of the self, people around them, society at large, and nature.
The Induction Program shall encompass (but not be limited to) below activities –

1. Physical Activities
2. Creative Arts
3. Exposure to Universal Human Values
4. Literary Activities
5. Proficiency Modules
6. Lectures by Experts / Eminent Persons
7. Visit to Local Establishments like Hospital /Orphanage
8. Familiarization to Department

The Induction Program Course does not have any marks or credits however performance of students for the Induction Program is assessed at the institute level using below mandatory criteria –

1. Attendance and active participation
2. Report writing

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Faculty of Engineering & Technology
NEP 2020 Compliant Curriculum

W.E.F. 2024-25 ***Semester III***

Distribution	*Course Code*	*Theory Course Name*	*Hrs./week*			*Credits*		*Examination Scheme*			
			L	*T*	*P*		*ESE*	*ISE*	*ICA*	*OE/POE*	*Total*
PCC	EEPCC-01	Analog Electronics	3			03	70	30			100
PCC	EEPCC-02	Power Plant Engineering and Elements of Power System	3			03	70	30			100
PCC	EEPCC-03	DC Machines and Transformer	3		2	04	70	30	25	25	150
CEP/FP	EEFP-01	Laboratory on Power Plant Engineering and Elements of Power System			2	01			25	25	50
CEP/FP	EEFP-02	Electrical Workshop			2	01			25	25	50
Entrepreneurship	EM-01	Product Development & Entrepreneurship	1	1		02		50	25		75
OE	OE-01	Open Elective -I	2		2	03	70	30	25		**125**
MDM	MDM-01	Multidisciplinary Minor -I	2		2	03	70	30	25		**125**
VEC	VEC-01	Universal Human Values	1		2	02	50*		25		**75**
	Total		**15**	**1**	**12**	**22**	**400**	**200**	**175**	**75**	**850**
	VEC-01	**Environmental Science**	**1**								

***For VEC-01(Universal Human Values) MCQ-based examination to be conducted. The red colour indicates activities that are connected with other programs**

PCC- Programme Core Course, PEC-Programme Elective Course, AEC - Ability Enhancement Course, IKS- Indian Knowledge System,
CC- Co-curricular Courses, VSEC-Vocational and Skill Enhancement Course, FP- Field Project/ CEP – Community Engagement Program
MDM-Multidisciplinary Minor: It should be selected from other UG Engineering Minor programs.

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Faculty of Engineering & Technology

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W.E.F. 2024-25 ***Semester IV***

Distribution	***Course Code***	***Theory Course Name***	***Hrs./week***			***Credits***		***Examination Scheme***			
			L	***T***	***P***		***ESE***	***ISE***	***ICA***	***OE/POE***	***Total***
PCC	EEPCC-04	Electrical Transmission and Distribution	3			03	70	30			100
PCC	EEPCC-05	Network Analysis	2		2	03	70	30	25		125
PCC	EEPCC-06	AC Machines	3		2	04	70	30	25	25	150
SEC	EESEC-01	Computer-Aided Design and Simulation	1		2	02			25	25	50
Economics/ Managements	EM-02	Project management economics	2			02		25	25		50
OE	OE-02	Open Elective -II	**2**		**2**	**03**	**70**	**30**	**25**		**125**
MDM	MDM-02	Multidisciplinary Minor -II	**2**		**2**	**03**	**70**	**30**	**25**		**125**
VEC	VEC-02	Professional Ethics	**1**		**2**	**02**	**50***		**25**		**75**
	Total		**16**		**12**	**22**	**400**	**175**	**175**	**50**	**800**
	Environmental Science		**1**				**40**	**10**			**50**

VEC-02 (Professional Ethics) Examination will be MCQ based

SEC- Skill Enhancement Course, PCC- Programme Core Course, VSEC-Vocational and Skill Enhancement Course

AEC- Ability Enhancement Course, EM Economice/ Managements, CC- Co-curricular Courses,

MDM-Multidisciplinary Minor: It should be from another UG Engineering Minor Programme..

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W.E.F. 2025-26 ***Semester V***

Distribution	*Course Code*	*Name of the Course*	*Engagement Hours*			*Credits*	*FA*	*SA*			*Total*
			L	*T*	*P*		*ESE*	*ISE*	*ICA*	*OE/ POE*	
PCC	EEPCC-07	Electromagnetic Engineering	3			03	70	30			100
PCC	EEPCC-08	Power System Analysis	3		2	04	70	30	25		125
PCC	EEPCC-09	Linear Control System	3		2	04	70	30	25	25	150
PEC	EEPEC-01	Programme Elective Course-I	3		2	04	70	30	25		125
AEC	AEC-02	Creativity and Design Thinking	1		2	02	50*		25		75
OE	OE-03	Interdisciplinary Mini Project	**1**		**2**	**02**			**25**	**25**	**50**
MD M	MDM-03	MD Minor-III	**2**		**2**	**03**	**70**	**30**	**25**		**125**
		Total	**16**		**12**	**22**	**400**	**150**	**150**	**50**	**750**

* MCQ examinations

PEC- Program Elective Course, PCC- Programme Core Course, VSEC-Vocational and Skill Enhancement Course

AEC- Ability Enhancement Course, IKS- Indian Knowledge System, CC- Co-curricular Courses,

MDM-Multidisciplinary Minor: It should be selected from other UG Engineering Minor programs.

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W.E.F. 2025-26 ***Semester VI***

Distribution	*Course Code*	*Name of the Course*	*Engagement Hours*			*Credits*	*FA*	*SA*			*Total*
			L	*T*	*P*		*ESE*	*ISE*	*ICA*	*OE/POE*	
PCC	EEPCC-10	Electric Traction & Utilization	2			02	70	30			100
PCC	EEPCC-11	Power Electronics & Industrial Drives	3		2	04	70	30	25	25	150
PCC	EEPCC-12	Advanced Control System	2		2	03	70	30	25		125
PEC	EEPEC-02	Program Elective Course-II	3		2	04	70	30	25	25	150
PEC	EEPEC-03	Program Elective Course-III	3	01		04	70	30	25		125
SEC	SEC-04	Mini Project on Industrial Applications			**4**	**02**			**25**	**50**	**75**
MDM	MDM-04	Multidisciplinary Minor-IV	**2**		**2**	**03**	**70**	**30**	**25**		**125**
		Total	**15**	**01**	**12**	**22**	**420**	**180**	**150**	**100**	**850**

PEC- Program Elective Course, PCC- Programme Core Course, SEC- Skill Enhancement Course
AEC- Ability Enhancement Course, IKS- Indian Knowledge System, CC- Co-curricular Courses,
MDM-Multidisciplinary Minor: It should be selected from other UG Engineering Minor programs.

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W.E.F. 2026-27 ***Semester VII***

Distribution	*Course Code*	*Name of the Course*	*Engagement Hours*			*Credits*	*FA*	*SA*			*Total*
			L	*T*	*P*		*ESE*	*ISE*	*ICA*	*OE/POE*	
PCC	EEPCC-13	Power Quality & FACTS	3			03	70	30			100
PCC	EEPCC-14	Switchgear & Protection	2		2	03	70	30	25		125
PEC	EEPEC-04	Programme Elective Course – IV or MOOCS	##4			04	100				100
Project	Project	Capstone Project			8*	04			100	100	200
RM	RM	Research Methodology and IPR	**3**		**2**	**04**	**70**	**30**	**25**		**125**
MD M	MDM-05	Multidisciplinary Minor-V	**2**			**02**	**70**	**30**			**100**
		Total	**14**		**12**	**20**	**350**	**150**	**175**	**125**	**800**

Students should attend MOOCS in that 4 Hrs. * Academic Load based on project groups
PEC- Program Elective Course, PCC- Programme Core Course, SEC- Skill Enhancement Course
AEC- Ability Enhancement Course, IKS- Indian Knowledge System, CC- Co-curricular Courses,
MDM-Multidisciplinary Minor: It should be selected from other UG Engineering Minor programs.

Punyashlok Ahilyadevi Holkar Solapur University, Solapur

Faculty of Engineering & Technology

NEP 2020 Compliant Curriculum

W.E.F. 2026-27 ***Semester VIII***

Distribution	*Course Code*	*Name of the Course*	*Engagement Hours*			*Credits*	*FA*	*SA*			*Total*
			L	*T*	*P*		*ESE*	*ISE*	*ICA*	*OE/POE*	
PCC	PCC-15	Electrical Energy Audit and Management	4#			04	100				100
PEC	PEC-05	Programme Elective Course –V or MOOCS	4#			04	100				100
OJT	OJT	On-Job Training			**24**	**12**			**200**	**100**	**300**
		Total	**8**		**24**	**20**	**200**		**200**	**100**	**500**

Self-learning Technical # Students will practice or attend in Self-Learning mode. *List of MOOC Courses related to Electrical PEC-04 & 05will be provided by BOS time to time

BSC- Basic Science Course ESC- Engineering Science Course, PCC- Programme Core Course,
AEC- Ability Enhancement Course, IKS- Indian Knowledge System, CC- Co-curricular Courses,
VSEC-Vocational and Skill Enhancement Course

Basket of Programme Elective Course (PEC)

PEC/Sem	Course code and name
EEPEC - 01/ V	EEPEC – 01A: Advanced Microcontroller Systems EEPEC – 01B: Advanced Electrical Machines EEPEC – 01C: Hybrid Electrical Vehicle Design
EEPEC - 02/ VI	EEPEC – 02A: Power System Operation and Control EEPEC – 02B: Electrical Machine Design EEPEC – 02C: Programmable Logic Control and SCADA
EEPEC - 03/ VI	EEPEC – 03A: Smart Grid Technology EEPEC – 03B Extra High Voltage AC Transmission EEPEC – 03C Energy Storage System EEPEC – 03D: Signal & System
EEPEC - 04/ VII OR	EEPEC – 04A: Electrical Estimation, Installation, and Testing EEPEC – 04B Mechatronics EEPEC – 04C: Neural Networks & Fuzzy Logic Control EEPEC – 04D: Digital Signal Processing
EEPEC - 04/ VII	MOOC Courses (As per the list provided by BOS)
EEPEC - 05/ VIII OR	EEPEC – 05A: High Voltage Engineering EEPEC – 05B: Instrumentation Process Control & Robotics EEPEC – 05C: Advanced Applications in Solar Energy Technology
EEPEC - 05/ VIII	MOOC Courses

Please identify two to three-course baskets as above, which students will opt for semester-wise PECs to develop expertise in the specific area.

A) Multidisciplinary Minor (MDM) in “Sustainable Energy System “

Semester	Course Code	Course Title
III	EEMDM-01A	Electrical Technology
IV	EEMDM-02A	Advanced Application in Renewable Energy
V	EEMDM-03A	Electrical Installation and Utilization
VI	EEMDM-04A	Energy Audit, Conservation Economics and Policy
VII	EEMDM-05A	Energy Storage Systems

Multidisciplinary Minors are for students of Other Programs.

B) Multidisciplinary Minor (MDM) in “Electric Vehicle Systems”

Semester	Course Code	Course Title
III	EEMDM-01B	Basics of Electric Vehicle
IV	EEMDM-02B	Electrical Vehicle Motors
V	EEMDM-03B	Electric Vehicle Controls
VI	EEMDM-04B	Electric Vehicle Battery Systems
VII	EEMDM-05B	AI & Cloud Computing in Electric Vehicles

Multidisciplinary Minors are for students of Other Programs.

A. Honors in **Electrical Vehicle**

Semester	*Course Code*	*Name of the Course*	*Engagement Hours*			*Credits*	*FA*	*SA*		*Total*
			L	*T*	*P*		*ESE*	*ISE*	*ICA*	
III	EEHn-01A	Electric Vehicle Technology	3		2	4	70	30	25	125
IV	EEHn-02A	Electric Motors and Controls for Electric Vehicles	3	1		4	70	30	25	125
V	EEHn-03A	Energy Management System for Electric Vehicle	3		2	4	70	30	25	125
VI	EEHn-04A	Testing And Certification of Electric And Hybrid Vehicles	3		2	4	70	30	25	125
VII	EEHn-05A	Mini Project			4*	2			50	50
		Total	**12**	**1**	**10**	**18**	**280**	**120**	**150**	**550**

* Indicates Contact Hours

The honors Course will be for the students of the same Program

B. Honors in **Sustainable Power Systems**

Semester	*Course Code*	*Name of the Course*	*Engagement Hours*			*Credits*	*FA*	*SA*		*Total*
			L	*T*	*P*		*ESE*	*ISE*	*ICA*	
III	EEHn-01B	Advanced and Sustainable Energy Sources	3		2	4	70	30	25	125
IV	EEHn-02B	Smart Energy Management System	3	1		4	70	30	25	125
V	EEHn-03B	Distributed Energy Integration	3		2	4	70	30	25	125
VI	EEHn-04B	AI Applications To Power Systems Management	3		2	4	70	30	25	125
VII	EEHn-05B	Mini Project			4*	2			50	50
		Total	**12**	**1**	**10**	**18**	**280**	**120**	**150**	**550**

*Indicates Contact Hours

The honors Course will be for the students of the same Program

Honors with Research

Semester	*Course Code*	*Name of the Course*	*Engagement Hours*	*Credits*	*SA*		*Total*
			P		*ICA*	*OE*	
VII	EERES-01	Research Project Phase-01	9 #	9	100	100	200
VIII	EERES-01	Research Project Phase-02	9 ##	9	100	100	200
		Total	18	18	200	200	400

Along with 9 hours of engagement hours, 4.5 Hrs. Activities for preparation for community engagement and service, preparation of reports, etc.

Along with 9 hours of engagement, 4.5 Hrs. Activities for preparation for community engagement and service, preparation of reports, etc., and independent reading during Project Phase 2, preferably related to Project Phase 2 activities.

These Courses are open to students of all the UG Engineering Program. However, Paper setting and evaluation responsibilities are assigned as follows:

Sr. No.	List of Open Electives	Responsible BOS	
1.	OE-01A: Advanced Mathematics and Statistics	General Engineering	**Semester III**
2.	OE-01B Digital Marketing and E-Commerce	Mechanical Engineering	
3.	OE-01C Humanities and Social Sciences	General Engineering	
4.	OE-01D Industrial and Quality Management	Mechanical Engineering	
5.	OE-01E Mathematics for Software and Hardware Applications	Electrical Engineering	
6.	OE-01F Soft Skills and Personality Development	General Engineering	

Sr. No.	List of Open Electives	Responsible BOS	
1.	OE-02A Entrepreneurship and Innovation	Civil Engineering	**Semester IV**
2.	OE-02B Environmental Sustainability	Civil Engineering	
3.	OE-02C Renewable Energy	Civil Engineering	
4.	OE-02D Measurement, Instrumentation & Sensors	Electrical Engineering	
5.	OE-02 E Operation Research	Mechanical Engineering	
6.	OE-02F Computational Mathematics	General Engineering	
7.	OE-02 G Professional Business Communication	General Engineering	

List of Open Electives 01 (Semester –III)

1. **OE-01A: Advanced Mathematics and Statistics**
2. **OE-01B Digital Marketing and E-Commerce**
3. **OE-01C Humanities and Social Sciences**
4. **OE-01D Industrial and Quality Management**
5. **OE-01E Mathematics for Software and Hardware Applications**
6. **OE-01F Soft Skills and Personality Development**

List of Open Electives 02 (Semester –IV)

1. **OE-02A Entrepreneurship and Innovation**
2. **OE-02B Environmental Sustainability**
3. **OE-02C Renewable Energy**
4. **OE-02D Measurement, Instrumentation and Sensors**
5. **OE-02E Operation Research**
6. **OE-02F Computational Mathematics**
7. **OE-02G Professional Business Communication**

Open Electives 03 (Semester –V)

1. **Interdisciplinary Mini Project**

Punyashlok Ahilyadevi Holkar Solapur University, Solapur

Name of the Faculty: Science & Technology

CHOICE BASED CREDIT SYSTEM

Subject: Electrical Engineering

Name of the Course: Final Year B. Tech

(Syllabus to be implemented from w. e. f. June 2026)

SEMESTER -I

	Punyashlok Ahilyadevi Holkar Solapur University, Solapur **Final Year B. Tech. Electrical Engineering** **Semester-I** **(EEPCC-13) Power Quality & FACTS**

Teaching Scheme	**Examination Scheme**
Theory– 3 Hrs. /Week, 3 Credits	**ESE**-70 Marks
	ISE- 30 Marks

Course Prerequisite:

Students should have basic knowledge of power systems, power electronics, and control systems. Understanding of transmission lines, reactive power control, and converter circuits is essential. Familiarity with harmonic analysis and phasor concepts will help in understanding compensator operation.

Course Objectives:

1. To understand various power quality disturbances, voltage variations, renewable energy integration issues, and international standards governing power quality.
2. To analyze harmonic generation in power systems and study methods for harmonic evaluation and mitigation using filters and standards.
3. To design and analyze passive and active harmonic filters for harmonic mitigation and study power quality monitoring techniques and measurement equipment used for diagnosing power quality problems in industrial and renewable energy systems.
4. To understand concepts of FACTS devices and analyze the operation and characteristics of shunt compensators like SVC and STATCOM.
5. To understand the objectives, concepts, operation, types, and performance characteristics of static series compensators used for power flow control.
6. To study advanced FACTS controllers such as UPFC and IPFC and their applications in modern power systems.

Course Outcomes:

Upon the successful completion of the course, students can

1. Understand the power quality issues & standards.
2. Analyze harmonic distortion, compute harmonic indices, and recommend suitable mitigation techniques as per IEEE/IEC guidelines.
3. Design and evaluate passive and active harmonic filters, and apply monitoring techniques to diagnose power quality problems
4. Compare and evaluate the performance characteristics of shunt FACTS devices such as SVC and STATCOM.

5. Analyze the operation and impact of series compensators on power transfer capability.
6. Distinguish the control structure and performance of advanced FACTS controllers.

SECTION-I

Unit 1: Introduction to Power Quality (06 Hrs.)

Terms and definitions: overloading, under voltage, over voltage, and power quality concepts. Voltage transients, short-duration and long-duration voltage variations, interruption, sustained interruption, voltage sag, voltage swell, voltage imbalance, voltage fluctuation, and power frequency variations. Power quality issues in PV and wind integrated systems. International standards of power quality.

Unit 2: Harmonics and Harmonic Evaluation (06 Hrs.)

Sources of harmonics from commercial and industrial loads, harmonic generation in converters and inverters used in PV and wind systems, locating harmonic sources, power system response characteristics, harmonics versus transients, effects of harmonics, voltage and current distortion, harmonic indices, inter-harmonics, resonance, harmonic distortion evaluation, IEEE and IEC harmonic standards.

Unit 3: Harmonic Filter Design and Power Quality Monitoring (08 Hrs.)

Need for harmonic mitigation, single-tuned and double-tuned passive filters, high-pass filters, design considerations of passive filters, shunt active power filters, series active power filters, hybrid filters, control strategies for active filters, and harmonic mitigation in renewable energy systems. Monitoring considerations, diagnostic techniques for power quality problems, and power quality measurement equipment.

SECTION-II

Unit 4: FACTS Concepts and Static Shunt Compensator (07 Hrs.)

Introduction of the FACTS devices, their importance in transmission networks, Basic types of FACTS controllers, Objectives of the shunt compensation, method of controller VAR generation, static VAR compensators: SVC and STATCOM, Comparison between V-I and V- Q Characteristics of STATCOM and SVC.

Unit 5: Static Series Compensators **(07 Hrs.)**

Objectives of series compensation, variable impedance type series compensators: GCSC, TSSC, TCSC, and SSSC, switching converter type series compensators, operating characteristics and applications of series compensators, impact on power transfer capability and system stability.

Unit 6: Advanced FACTS Controllers **(06 Hrs.)**

Objectives of voltage and phase angle regulators, TCVR and TCPAR concepts, basic operating principles of UPFC, control structure of UPFC, operating principles and characteristics of IPFC, control structure and applications of IPFC, comparison between UPFC and IPFC.

Text Books:

1. Hingorani, N. G., & Gyugyi, L. (2000). *Understanding FACTS: Concepts and technology of flexible AC transmission systems*. Standard Publishers.
2. Padiyar, K. R. (2007). *FACTS controllers in power transmission and distribution*. New Age International Publishers.
3. R.C. Dugan, Mark F.Mc Granaghan, Surya Santoso, and H. Wayne Beaty, "Electrical Power System Quality", 2nd Edition, McGraw Hill Publication.

Reference Books:

1. Miller, T. J. E. (1982). Static reactive power compensation: A guide to the technology and applications for power system operators, planners, and engineers. John Wiley & Sons.
2. Arrillaga, J., & Watson, N. R. (2003). Power system harmonics. John Wiley & Sons.
3. Ghosh, A., & Ledwich, G. (2002). Power quality enhancement using custom power devices. Kluwer Academic Publishers.
4. Bollen, M. H. J. (2000). Understanding power quality problems: Voltage sags and interruptions. IEEE Press/Wiley.

	Punyashlok Ahilyadevi Holkar Solapur University, Solapur **Final Year B. Tech. Electrical Engineering** **Semester-I** **(EEPCC-14) Switchgear & Protection**

Teaching Scheme	**Examination Scheme**
Theory– 2 Hrs. /Week, 2 Credits	**ESE**-70 Marks
Practical– 2 Hrs. /Week, 1 Credit	**ISE**- 30 Marks
	ICA- 25 Marks

Course Prerequisite:

Students should have basic knowledge of power system components, fault analysis, and electrical machines. Understanding of three-phase systems, phasor concepts, and circuit analysis is essential. Familiarity with power system operation will help in understanding protection schemes and relay coordination.

Course Objectives

1. To understand the need and fundamentals of power system protection and relay operation.
2. To study overcurrent and differential protection schemes with relay coordination.
3. To learn distance protection principles and relay characteristics.
4. To understand the protection of transformers, generators, motors, and bus-bars.
5. To study arc interruption and performance parameters of circuit breakers.
6. To understand the types, construction, and testing of circuit breakers.

Course Outcomes: On completion of the course, students will be able to-

1. Apply the principles of protective relaying to analyze zones of protection and operation of electromagnetic and static relays.
2. Explain overcurrent and differential protection schemes.
3. Apply protection schemes for different power system equipment.
4. Explain the protection schemes used for transformers, generators, induction motors, and bus bars by describing various faults, abnormal operating conditions
5. Describe the concept of electric arc and the principles of arc interruption in circuit breakers, including transient phenomena such as TRV, recovery voltage, and RRRV
6. Explain the classification, construction, operation, ratings, testing, and applications of various circuit breakers and isolators used in electrical power systems.

SECTION-I

Unit-1: Protective Relays **(05 Hrs.)**

Need of protective relaying, Desirable qualities, zone of protection, primary & backup protection, attracted armature, balanced beam, moving coil relays, theory and construction of induction disc and induction cup type electromagnetic relays, theory of torque production in induction relays, static relay.

Unit-2: Over Current Protection and Differential Protection **(06 Hrs.)**

Fuse: Rewirable and HRC fuse, fuse characteristics, application, and selection of fuse. Plug Setting, time setting multiplier (Simple numerical on PSM & TSM), radial feeder and ring mains protection, relay coordination, earth fault and phase fault relays, directional relay, static relay (block diagram for overcurrent relays), microprocessor-based o/c relay, numerical on overcurrent relays.

Unit-3: Distance Protection **(05 Hrs.)**

Impedance, reactance, and admittance characteristics relay settings for 3-zone protection, carrier-aided protection scheme, electromagnetic and static relays for transmission line protection, and microprocessor-based impedance, reactance, and mho relays

SECTION-II

Unit-4: Equipment Protection **(06 Hrs.)**

Transformer protection: Different types of faults in the transformer, overcurrent protection of the transformer, percentage differential protection of the transformer, Buchholz relay for incipient faults, protection against over-fluxing

Generator protection: stator earth fault, phase fault, stator current unbalance (NPS) protection, rotor overheating, earth fault protection, excitation failure, and protection against motoring, and generator-transformer unit protection.

Induction motor protection - Protection of induction motors against different faults and abnormal conditions

Bus-bar protection – Introduction, Differential protection of bus-bars.

Unit-5: Circuit Breakers: **(05 Hrs.)**

Voltage-current characteristics of arc, principles of DC and AC arc interruption, high resistance and current zero interruption, arc voltage, the expression for transient re-striking voltage (TRV), recovery voltage, RRRV and resistance switching, current chopping, capacitive current interruption, Simple numerical on the calculation of TRV, RRRV, etc.

Unit-6: Types of Circuit Breakers: (05 Hrs.)

Classification of circuit breakers, brief study of construction and working of bulk oil and minimum oil CB, Air break and Air Blast CB, SF6 and Vacuum CB, MCB and MCCB, HVDC breakers, Ratings of CB and testing of CB, Isolator

Textbooks:

1. Power System Protection and Switchgear: B.Ram and B.N. Vishwakarma
2. Fundamentals of Power System Protection: Paithankar Y G and Bhide S R, PHI publication, EEE 2003
3. Switchgear and Protection: Sunil.S. Rao, Khanna Publications
4. Switchgear and protection: J B Gupta, S K Kataria and Sons

Reference Books:

1. Power Systems Protection and Switch Gear: Ravindranath B., Chander, N., Wiley Eastern Ltd.
2. Protective Relaying: Principles and Applications: J. Lewis Blackburn, Thomas J. Domin, CRC Press
3. Computer Relaying for Power System: A. G. Phadke, J. S. Thorp: Research Studies Press LTD, England (John Willy & Sons Inc., New York)
4. Handbook of switchgear: Bharat Heavy Electricals Limited, McGraw Hill Publication
5. Electrical Power Systems - Dr. S.L. Uppal & Prof. S. Rao, Khanna Publishers
6. A Web course on “Digital Protection of Power System” by Prof. Dr S. A. Soman, IITMumbai
7. For MCCB:- http://electrical-engineering-portal.com/download-center/books-and-guides/electrical-engineering/basics-of-molded-case-circuit-breakers-mccbs.

ICA:

Minimum six experiments shall be performed from the given list, along with two drawing sheets based on the above syllabus.

List of experiments: -

1. Experimental realization of an electromechanical overcurrent relay.
2. Experimental realization of a static overcurrent/earth fault relay.
3. Experimental realization of a numerical overcurrent/earth fault relay.
4. Experimental realization of three-phase transformer protection with a % differential relay.
5. Experimental realization setup of a circuit breaker.
6. Experimental realization of distance protection of transmission line.
7. Experimental realization of three-phase induction motor protection.
8. Experimental realization of Merz-Price protection of an alternator.
9. Simulate overcurrent protection of a transmission line using a relay and circuit breaker.
10. Simulate combined phase fault and earth fault protection.
11. Overcurrent and Earth Fault Relay Setting Using MATLAB

	Punyashlok Ahilyadevi Holkar Solapur University, Solapur **Final Year B. Tech. Electrical Engineering** **Semester-I** **(EEPEC-04A) Electrical Estimation, Installation, and Testing**

Teaching Scheme	**Examination Scheme**
Theory– 4 Hrs. /Week, 4 Credits	**ESE**-100 Marks

- **Course Prerequisite:** Students should have basic knowledge of electrical machines, transformers, wiring systems, and power system fundamentals. Familiarity with electrical safety practices and basic testing instruments is essential for understanding installation, testing, and maintenance procedures.
- **Course Objectives**

1. To understand electrical safety practices, statutory regulations, IS/IEC standards, and accident prevention methods in electrical installations.
2. To learn estimating techniques and perform conductor size calculations for wiring, cables, and overhead lines.
3. To understand the installation practices of electrical machines, foundations, alignment, and earthing systems.
4. To study testing procedures for rotating machines, transformers, insulation, and insulating oil as per relevant IS/IEC standards.
5. To understand routine, preventive, and breakdown maintenance practices of electrical equipment.
6. To study the classification, properties, testing, and applications of insulating materials used in electrical equipment and accessories.

- **Course Outcomes: On completion of the course, students will be able to**

1. Explain electrical safety rules, statutory provisions, IS/IEC standards, and accident prevention methods.
2. Calculate conductor sizes and prepare cost estimates for electrical installations.
3. Demonstrate proper installation, alignment, and earthing procedures for electrical equipment.
4. Perform standard tests on rotating machines, transformers, insulation, and insulating oil as per IS/IEC standards.
5. Analyze maintenance requirements and develop preventive maintenance schedules for electrical equipment.
6. Classify insulating materials and evaluate their properties, applications, and testing methods used in electrical systems.

SECTION I

Unit 1: Safety and Prevention of Accidents (08 Hrs.)

Definition of terminology used in safety; safety, hazard, accident, major accident hazard, responsibility, authority, accountability, monitoring, Indian Electricity Act & statutory regulations for safety of persons & equipment working with electrical installation, IS and IEC safety standards related to electrical installations and protection practices, Do's & don'ts for substation operators as listed in IS, Meaning & causes of electrical accidents, factors on which severity of shock depends, Procedure for rescuing the subjected to an electric shock, methods of providing artificial respiration, Precautions to avoid fire due to electrical reasons, operation of fire extinguishers.

Unit 2: Estimating and Conductor Size Calculations (08 Hrs.)

Meaning and objectives of estimating, steps involved in preparation of estimate, price catalog, schedule of labor rates, schedule of rates and estimating data. Determination of conductor size based on current carrying capacity, voltage drop, temperature rise, and minimum permissible size as per IS/IEC standards. Conductor size calculations for internal domestic wiring with simple numericals, conductor size calculations for underground cables with simple numericals, conductor size calculations for overhead lines using ACSR conductors with simple numericals.

Unit 3: Electrical Installation (08 Hrs.)

Factors involved in designing the machine foundation, Requirement of dimensions of foundation for static & rotating machines, procedure for leveling & alignment of two shafts of directly & indirectly coupled drives, effects of misalignment, Installation of rotating machines as per I.S.900-1992 and relevant IEC standards, Importance and purpose of earthing, types of earthing- Pipe and Plate Earthing.

SECTION-II

Unit 4: Testing of Rotating Machines, Transformer, and Insulation (10 Hrs.)

Objectives and significance of testing, importance of IS and IEC standards in testing of electrical equipment. Tests on electrical machines before commissioning, concept of routine tests, type tests, special tests, supplementary test on the transformer and rotating machine, induced over-voltage, and Impulse voltage withstand the test of the transformer, Classification of insulating materials as per IS 8504 (part III) 1994 and IEC insulation classes, factors affecting the life of insulating materials, Properties of good transformer oil, list the agents which contaminate the insulating oil, understand the procedure of following tests on oil as per IS 1692 and IEC 60156, acidity test, flash point test, crackle test, sludge test, dielectric strength test.

Unit 5: Maintenance of Rotating Machines, Transformer and Insulation (07 Hrs.)

Concept of routine, preventive & breakdown maintenance, comparison of Preventive and breakdown maintenance, comparison of routine and breakdown maintenance, procedure for developing preventive maintenance schedule, Factors affecting preventive maintenance schedule, Introduction to total productive maintenance (TPM), Routine, Preventive maintenance of transformer

Unit 6: Electrical Insulation (07 Hrs.)

Definition and importance of insulation, requirements of good insulating materials. Classification and types of insulating materials: solid, liquid, and gaseous insulation with applications in transformers, cables, motors, and switchgear.

Thermal classification of insulating materials as per IS/IEC standards: Class Y, A, E, B, F, H, and C. Dielectric properties of insulating materials: dielectric strength, dielectric loss, and dielectric constant. Factors affecting insulation performance.

Breakdown mechanisms in solid, liquid, and gaseous insulation. Insulation resistance measurement using Megger. Testing of insulating materials: dielectric strength test and insulation resistance test.,

- **Textbooks:**

1. S. Rao "Testing & Commissioning Of Electrical Equipment ", Khanna Publishers
2. B .V. S. Rao, "Testing & Commissioning Of Electrical Equipment", Media Promoters and Publication Pvt., Ltd.

- **Reference Books:**

1. Uppal .S. L – Electrical Wiring, Estimation & Costing (Khanna Publication).
2. Raina & Bhattacharyya – Electrical Design Estimating & Costing (Willy Eastern).
3. Relevant Bureau of Indian Standards
4. H. N. S. Gowda, "A Handbook on Operation and Maintenance of Transformers", Published by H. N. S. Gowda

	Punyashlok Ahilyadevi Holkar Solapur University, Solapur **Final Year B. Tech. Electrical Engineering** **Semester-I** **(EEPEC-04B) Mechatronics**

Teaching Scheme	Examination Scheme
Theory– 4 Hrs. /Week, 4 Credits	**ESE**-100 Marks

Course Prerequisite:

Students should have prior knowledge of ADC, DAC, microcontroller interfacing, and basic communication protocols. Understanding of electromechanical systems, sensors, actuators, and control fundamentals is essential for studying mechatronics system design and modeling.

Objectives:

This course aims:

1. To explain the fundamental elements, design process, and types of traditional and mechatronics systems.
2. To Analyze mechanical configurations by identifying various types of motion and the kinematic chains that drive them.
3. To develop and validate mathematical models of electro-mechanical and mixed-domain systems.
4. To describe and apply single and multi-channel interfacing techniques using standard communication protocols.
5. To analyze various real-time mechatronics systems and their control strategies.
6. To explain the principles, design considerations, and applications of micro-mechatronics systems.

Course outcomes:

At the end of this course, students will be able to:

1. Explain key elements and design processes of traditional and mechatronics systems.
2. Analyze mechanical configurations by identifying various types of motion and the kinematic chains that drive them.
3. Develop and validate mathematical models of mixed-domain systems.
4. Apply interfacing techniques and implement communication standards in mechatronics systems.
5. Analyze and evaluate case studies of mechatronics systems and their control mechanisms.
6. Design and assess micro-mechatronics systems based on scaling laws and application requirements.

SECTION I

Unit 1: Fundamentals **(08 Hrs.)**

Definition and scope of Mechatronics, Mechatronics system concept and architecture, Key elements of Mechatronics: sensors, actuators, signal conditioning, controllers, microprocessors, Mechatronics design process: need identification, conceptual design, modeling, analysis, prototyping, testing, Types of design: traditional design, concurrent engineering, integrated design, Design parameters: performance, cost, reliability, maintainability, safety, Comparison between traditional mechanical design and Mechatronics design

Unit 2: Mechanical actuation systems **(08 Hrs.)**

Overview of mechanical systems in Mechatronics, Types of motion: linear, rotary, reciprocating, oscillatory, Kinematic chains and mechanisms, Cam and follower: types and applications, Gear trains: simple, compound, epicyclic, Ratchet and pawl mechanism, Belt drives and chain drives: types and applications, Bearings: types, selection criteria, lubrication aspects, Mechanical considerations in motor selection: load, torque-speed characteristics

Unit 3: System Modelling **(08 Hrs.)**

Introduction to system modelling and its importance, Model categories: physical, mathematical, analytical, simulation, Fields of application of system models, Steps in model development, Model verification and validation techniques, Model simulation methods, Design of mixed systems (mechanical, electrical, electronic integration), Electromechanical system modelling, Model transformation techniques, Domain-independent description forms, Simulator coupling and co-simulation

SECTION-II

Unit 4: System Interfacing **(08 Hrs.)**

Introduction to interfacing in Mechatronics systems, Selection criteria for interface cards, Data Acquisition (DAQ) systems: concept and working, Single-channel and multi-channel DAQ systems, Serial communication: RS232, RS422, RS485 standards, IEEE 488 (GPIB) interface standard, Graphical User Interface (GUI): basics and applications, Ethernet-based communication and switches, Man–Machine Interface (MMI) concepts and design

Unit 5: Case Studies of Mechatronics System **(08 Hrs.)**

Introduction to Mechatronics system integration through case studies, Fuzzy logic-based washing machine, pH control system, Autofocus camera system, Exposure control system, Motion control using DC motor, Solenoid-based actuation systems, Engine management system, Temperature control system using PID controller

Unit 6: Micro Mechatronics System **(08 Hrs.)**

Introduction to micro-mechatronics and MEMS, System principles at micro-scale, Micro-scale component design, Micro-system design considerations, Scaling laws in micro systems, Micro actuation techniques, Micro robots: concept and applications, Micro pumps: design and working, Applications of micro-mechatronics in engineering and biomedical fields

Textbooks:

1. Devadas Shetty, Richard A.Kolkm, "Mechatronics system design, PWS publishing company, 2009.
2. Shetty, D., & Kolk, R. A. (2009). Mechatronics system design. PWS Publishing Company.
3. Bolton, W. (2009). Mechatronics: Electronic control systems in mechanical and electrical engineering (2nd ed.). Addison Wesley Longman.
4. Morris, B. (2000). Automated manufacturing systems: Actuators, controls, sensors, and robotics. McGraw-Hill International Edition.
5. Bradley, D., Dawson, N., Burd, N. C., & Loader, A. J. (1999). Mechatronics: Electronics in products and processes. Chapman & Hall.

Reference Books

1. Hristu-Varsakelis, D., & Levine, W. S. (Eds.). (2005). Handbook of networked and embedded control systems. Birkhäuser.
2. Mahalik, N. P. (2003). Mechatronics: Principles, concepts and applications. Tata McGraw-Hill.
3. Bishop, R. H. (Ed.). (2002). The mechatronics handbook. CRC Press.

	Punyashlok Ahilyadevi Holkar Solapur University, Solapur **Final Year B.Tech Electrical Engineering** **Semester-I** **(EEPEC-04C) Neural Networks & Fuzzy Logic Control**

Teaching Scheme	Examination Scheme
Theory– 4 Hrs. /Week, 4 Credits	**ESE**-100 Marks

Course Prerequisite: Students should have knowledge of linear algebra, probability, and basic control systems. Understanding of signals and systems, matrix operations, and basic programming concepts is essential for studying neural networks and fuzzy logic control.

Objectives:

1. To introduce the fundamental concepts of artificial neural networks, including neuron models, architectures, and learning mechanisms.
2. To explain supervised learning techniques such as perceptron and backpropagation algorithms for training neural networks.
3. To analyze advanced neural network models including associative memory networks and recurrent networks.
4. To develop understanding of fuzzy set theory, fuzzy relations, and fuzzy inference mechanisms.
5. To illustrate the design and operation of fuzzy logic controllers for control system applications.
6. To integrate neural networks and fuzzy logic concepts for developing hybrid intelligent systems.

Course outcomes: After completion of the course, students will be able to:

1. Explain the fundamental concepts, architectures, and learning rules of artificial neural networks.
2. Apply supervised learning algorithms such as perceptron and backpropagation for solving classification problems.
3. Analyze the performance and structure of advanced neural networks including associative and recurrent networks.
4. Apply fuzzy set theory concepts including membership functions, operations, and fuzzy relations to solve problems.
5. Design and implement fuzzy logic controllers using fuzzification, inference mechanisms, and defuzzification methods.
6. Evaluate and develop hybrid intelligent systems by integrating neural networks and fuzzy logic techniques.

SECTION I

Unit I: Fundamentals of Neural Networks (08 Hrs.)

Introduction to neural networks, Motivation for development of neural networks, Biological neurons vs. artificial neurons, Basic structure of artificial neuron, Typical neural network architectures, Applications of neural networks, Setting of weights and biases, Common activation functions, Basic learning rules, McCulloch–Pitts neuron: model and applications

Unit II: Supervised Learning Techniques (08 Hrs.)

Single-layer neural networks for pattern classification, Biases and thresholds, Linear separability, Hebb's learning rule, Perceptron model and algorithm, Perceptron convergence theorem, Delta learning rule, Limitations of single-layer networks

Unit III: Multilayer & Advanced Neural Networks (08 Hrs.)

Multilayer neural networks, Need for hidden layers, Back propagation neural network, Architecture and working of back propagation algorithm, Derivation of learning rules, Training issues and convergence, Associative memory networks: auto-associative and hetero-associative, Bidirectional Associative Memory (BAM), Hopfield networks, Boltzmann machines (basic concept and applications)

SECTION II

Unit IV: Fundamentals of Fuzzy Logic (08 Hrs.)

Basic concepts of fuzzy set theory, Crisp sets vs. fuzzy sets, Membership functions, Fuzzy set operations: complement, union, intersection, Combination of operations, General aggregation operations, Fuzzy relations, Compatibility relations, Orderings and morphisms, Fuzzy relational equations

Unit V: Fuzzy Logic Control Systems (08 Hrs.)

Introduction to fuzzy logic control, Structure of fuzzy logic controller, Fuzzification methods, Knowledge base and rule base, Inference mechanisms (Mamdani and Sugeno methods), Defuzzification methods, Design of fuzzy controllers, Stability and performance considerations

Unit VI: Advanced & Hybrid Intelligent Systems (08 Hrs.)

Adaptive fuzzy systems, Fuzzy Associate Memories (FAM), Neuro-fuzzy systems, Integration of neural networks and fuzzy logic, Cognitron and Neocognitron: architecture and training, Comparison of neural networks and fuzzy systems, Applications of hybrid intelligent systems

Textbooks:

1. Klir, G. J., & Yuan, B. (1995). Fuzzy sets and fuzzy logic: Theory and applications. Prentice Hall of India.
2. Fausett, L. (1994). Fundamentals of neural networks: Architectures, algorithms, and applications. Prentice Hall.
3. S. N. Sivanandam, S. Sumathi, and S. N. Deepa, Introduction to Neural Networks using MATLAB, McGraw Hill.
4. Timothy J. Ross, Fuzzy Logic with Engineering Applications, Wiley India.

Reference Books:

1. Kosko, B. (1994). Neural networks and fuzzy systems: A dynamical systems approach to machine intelligence. Prentice Hall.
2. Klir, G. J., & Folger, T. A. (1988). Fuzzy sets, uncertainty, and information. Prentice Hall.
3. Zurada, J. M. (1992). Introduction to artificial neural systems. Jaico Publishing House.
4. Rao, V., & Rao, H. (1996). C++ neural networks and fuzzy logic. BPB Publications.
5. NPTEL. (n.d.). Intelligent systems and control. https://nptel.ac.in/courses/108104049/
6. Stamatios V. Kartalopoulos, Understanding Neural Networks and Fuzzy Logic: Basic Concepts and Applications, IEEE Press.

	Punyashlok Ahilyadevi Holkar Solapur University, Solapur Final Year B. Tech. Electrical Engineering Semester-I (EEPEC-04D) Digital Signal Processing

Teaching Scheme	Examination Scheme
Theory– 4 Hrs. /Week, 4 Credits	**ESE**-100 Marks

Course Prerequisite:

Students should have prior knowledge of signals and systems, DFT, FFT, and basic IIR and FIR filter design. Understanding of Z-transform, convolution, and basic programming concepts is essential for digital signal processing applications.

Course Objectives:

1. To introduce the fundamental concepts of Digital Signal Processing and DSP architectures.
2. To explain the principles and computational techniques of Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT).
3. To provide knowledge of modern transforms such as DCT and Wavelet Transform for signal analysis.
4. To develop the ability to design and analyze IIR digital filters using standard techniques.
5. To design FIR filters using various methods and understand their practical implementation issues.
6. To introduce adaptive filtering concepts and algorithms for real-time signal processing applications.

Course Outcomes

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

1. Explain DSP fundamentals, architectures, and applications in engineering systems.
2. Apply DFT and FFT algorithms for spectral analysis and signal processing.
3. Analyze and apply modern transforms such as DCT and Wavelet Transform.
4. Design and implement IIR filters using impulse invariant and bilinear transformation techniques.
5. Design FIR filters using windowing and frequency sampling methods and evaluate their performance.
6. Apply adaptive filtering techniques such as LMS algorithm for real-world applications.

SECTION-I

Unit 1: Introduction **(06 Hrs.)**

Introduction to Digital Signal Processing (DSP), DSP system concept and block diagram, DSP processor architecture: basic features and components, Comparison of analog and digital signal processing, Advantages and limitations of DSP systems, Applications of DSP in engineering systems, Applications in power systems for measurement of electrical quantities (voltage, current, power), power system protection, signal monitoring and analysis

Unit 2: Discrete Fourier Transform and FFT (12 Hrs.)

Correlation: definition, types, and properties, Discrete Fourier Transform (DFT): definition and computation, relationship between DFT and Z-transform, Properties of DFT: linearity, periodicity, symmetry, time and frequency shifting, Circular convolution and its properties, Relationship between linear and circular convolution, Fast Fourier Transform (FFT): need and computational advantages, FFT algorithms (DIT FFT & DIF FFT), Implementation aspects of FFT algorithms, Inverse FFT (IFFT), Use of DFT in linear filtering, Filtering of long data sequences such as Overlap- save and Overlap Overlap-add method, Frequency analysis of signals using DFT

Unit 3: Modern Transforms (06 Hrs.)

Introduction to Discrete Cosine Transform (DCT), Inverse Discrete Cosine Transform (IDCT), Applications of DCT in signal and image processing, Introduction to Wavelet Transform, Continuous Wavelet Transform (CWT), Discrete Wavelet Transform (DWT), Properties of Discrete Wavelet Transform, Comparison of Fourier Transform and Wavelet Transform

SECTION - II

Unit4: IIR Filters Design (10 Hrs.)

Introduction to digital filters, Classification of digital filters: IIR and FIR filters, Comparison of analog and digital filters, Analog filter approximation techniques: Butterworth filters, IIR filter design using Impulse Invariant technique, Bilinear transformation, Frequency transformation techniques, Stability considerations in IIR filters, Finite world length effects in IIR filters, Implementation of IIR filters: direct form and cascade structures

Unit 5: FIR Filter Design (08 Hrs.)

Introduction to FIR filters, Characteristics and properties of FIR Filters, Linear phase property of FIR filters, windowing method and frequency sampling method of filter design, Comparison of FIR and IIR filters, finite word length effects in FIR filters, FIR Implementation techniques

Unit 6: Adaptive Filters (06 Hrs.)

Introduction to adaptive signal processing, Concept of adaptive filtering, Structure of adaptive filters, Adaptive direct form FIR filters, Least Mean Square (LMS) algorithm, Applications of adaptive filters: noise cancellation, system identification

Textbooks:

1. Proakis, J. G., & Manolakis, D. G. (2007). Digital signal processing: Principles, algorithms, and applications (4th ed.). Pearson Education.
2. Palani, S., & Kalaiyarasi, D. (2010). Digital signal processing. Ane Books Pvt. Ltd.
3. Babu, R. (2014). Digital signal processing (4th ed.). Scientific Publishers.

Reference Books:

1. Ifeachor, E. C., & Jervis, B. W. (2002). Digital signal processing: A practical approach (2nd ed.). Pearson Education.
2. Salivahanan, S., Vallavaraj, A., & Gnanapriya, C. (2011). Digital signal processing. Tata McGraw-Hill.
3. Oppenheim, A. V., & Schafer, R. W. (2010). Discrete-time signal processing (3rd ed.). John Wiley & Sons.
4. Schilling, R. J., & Harris, S. L. (2012). Fundamentals of digital signal processing using MATLAB. Cengage Learning.
5. Hayes, M. H. (1999). Digital signal processing (Schaum's outline series). Tata McGraw-Hill.

	Punyashlok Ahilyadevi Holkar Solapur University, Solapur **Final Year B. Tech. Electrical Engineering** **Semester-I** **(EEPEC-04) MOOC**

Teaching Scheme	**Examination Scheme**
Theory– 4 Hrs. /Week, 4 Credits	**ESE-**100 Marks

Students can select & enroll for an approved minimum **twelve-week technical course** from various NPTEL/SWAYAM technical courses, or any other approved MOOC platform, complete its assignments, and appear for a certification examination conducted by NPTEL, SWAYAM, Or respective MOOC platform.

BOS Chairman / Coordinator will announce the list of approved NPTEL/MOOC online courses/areas of minimum twelve-week duration for 'Programme Elective Course-IV' from the available NPTEL/SWAYAM/ MOOC courses and will make them available to students through the University website.

List of approved NPTEL/MOOC online courses/areas of minimum **twelve-week** duration based on the following areas

- Electric Vehicles
- Automation and Robotics
- Artificial intelligence
- Machine Learning and Deep Learning
- Sustainable Power System
- Advanced Power Electronic and Control
- Design of Photovoltaic system
- Advance Electrical Drives
- Embedded Systems for Electrical Applications
- Industrial Internet of Things (IIoT)
- Cyber Security in Power Systems
- Green Hydrogen and Energy Systems
- Digital Twin Technology for Power Systems
- AI Applications in Power Systems

	Punyashlok Ahilyadevi Holkar Solapur University, Solapur Final Year B. Tech. Electrical Engineering Semester-I (Project) Capstone Project

Teaching Scheme	Examination Scheme
Practical: - 8 Hrs/Week, 4 Credits	**ICA**- 100 Marks
	OE- 100 Marks

Course Prerequisite:

Students shall have basic knowledge of core engineering disciplines, be familiar with programming languages/CAD design, understanding of project management principles.

Course Objectives

1. To enable students to identify and formulate real-world engineering problems relevant to electrical engineering.
2. To develop the ability to carry out literature survey and analyze existing solutions.
3. To design and implement technically feasible solutions using appropriate tools and techniques.
4. To enhance skills in project planning, execution, and documentation.
5. To promote teamwork, communication, and professional ethics in project development.
6. To encourage innovation through industry-oriented or in-house project work.

Course Outcomes: After completion of the course, students will be able to:

1. Identify and formulate a relevant engineering problem through literature review.
2. Analyze and select appropriate methodologies and tools for problem solving.
3. Design and implement a working solution for the defined problem.
4. Evaluate system performance and validate results through testing.
5. Demonstrate effective teamwork, communication, and project management skills.
6. Prepare and present a comprehensive technical report following professional standards.

Instructions to Students

1. The Capstone Project shall be carried out within a single semester (Semester VII)**.**
2. Students shall work in groups (Max 4) and select Industry-sponsored / sponsored / In-house projects**.**
3. The project shall include the Problem identification and finalization, Literature survey and review of existing work, Preparation and submission of project synopsis, System design and methodology selection, Implementation and testing of the proposed system, Result analysis and validation stages.

4. Students must deliver a seminar presentation based on their project progress.
5. A synopsis report shall be submitted after approval of the problem statement.
6. A final hard copy of the project report shall be submitted upon successful completion of the project and maintained in the Institute records.
7. Projects should emphasize practical implementation, innovation, real-world applicability and alignment with Sustainable Development Goals (SDGs).
8. Students are encouraged to use modern tools, software, and hardware platforms**.**
9. Projects may be selected from, but are not limited to, the following domains:
   - Power Systems and Smart Grid
   - Electrical Machines and Drives
   - Power Electronics and Control Systems
   - Renewable Energy Systems (Solar, Wind, Hybrid Systems)
   - Electric Vehicles and Energy Storage Systems
   - Automation, Robotics, and Industrial Control
   - Embedded Systems and IoT Applications
   - Artificial Intelligence and Machine Learning in Electrical Engineering
   - Signal Processing and Communication Systems
   - Energy Management and Audit Systems

A. Multidisciplinary Minor in “Sustainable Energy System”

Sem	Course Code	Title
VII	EEMDM-05 A	Energy Storage Systems

	Punyashlok Ahilyadevi Holkar Solapur University, Solapur **Final Year B. Tech. Electrical Engineering** **Semester-I** **(EEMDM-05A) Energy Storage Systems**

Teaching Scheme	**Examination Scheme**
Theory: - 2 Hrs/Week, 2 Credits	**ESE-** 70 Marks
	ISE- 30 Marks

Course Prerequisite:

Basic understanding of physics (energy, power, basic electricity concepts) and general awareness of renewable energy systems. No prior electrical engineering background is required.

Course Objectives

1. To explain the need and importance of energy storage in modern energy systems.
2. To describe battery types, characteristics, and applications in EVs and solar systems.
3. To understand battery management, safety issues, and lifecycle considerations.
4. To explain mechanical and thermal energy storage methods and their applications.
5. To analyze electrical energy storage systems and their role in power quality and backup.
6. To discuss emerging trends and assess the future scope of advanced energy storage technologies

Course Outcome: Upon successful completion of this course, a student should be able to:

1. Explain the role and importance of energy storage in renewable energy integration and smart grids.
2. Describe battery types, characteristics, and applications in EVs and solar systems.
3. Understand battery management, safety issues, and lifecycle considerations.
4. Explain mechanical and thermal energy storage methods and their applications.
5. Analyse electrical energy storage systems and their role in power quality and backup.
6. Discuss emerging trends and assess the future scope of advanced energy storage technologies

SECTION-I

Unit 1: Introduction to Energy Storage **(5 Hours)**

Energy scenario and need for storage, Role of energy storage in renewable energy systems, Basic energy and power concepts, Applications in grid, electric vehicles, and portable devices, Overview of energy storage technologies, Energy storage in homes (solar + battery systems), introduction to Battery Energy Storage System (BESS), Case studies: Solar home system, EV charging station.

Unit 2: Electrochemical Energy Storage – Batteries **(5 Hours)**

Basic battery terminology, Primary and secondary batteries, Lead-acid batteries, Lithium-ion batteries, Comparison of battery technologies, Battery packs in electric vehicles, Battery sizing for solar rooftop systems, Performance parameters: capacity, efficiency, life cycle, applications in EVs, solar systems, and BESS.

Unit 3: Battery Management, Safety, and Grid Interfacing **(5 Hours)**

Need for Battery Management System (BMS), State of Charge (SOC) and State of Health (SOH), charging methods, thermal management, battery safety issues, thermal runaway and precautions, battery degradation and recycling. Introduction to grid interfacing of batteries, battery control in solar and microgrid applications, basic concepts of bidirectional power flow and inverter interfacing.

Unit 4: Mechanical and Thermal Energy Storage **(5 Hours)**

Pumped hydro storage, Flywheel energy storage, Compressed air energy storage (CAES), Thermal energy storage systems, basic working principles, advantages, limitations, and applications.

Unit 5: Electrical Energy Storage Systems **(5 Hours)**

Supercapacitors, Ultra-capacitors, Superconducting magnetic energy storage (SMES), Hybrid energy storage systems, Applications in power quality improvement, Backup systems for hospitals and data centers introduction to microgrid applications.

Unit 6: Emerging Trends and Applications **(5 Hours)**

Hydrogen energy storage, fuel cells, solid-state batteries, smart grid applications, EV charging infrastructure, role of energy storage in sustainable development, renewable energy integration, and carbon neutrality.

Textbooks:

1. Linden, D., & Reddy, T. B. (Eds.). (2011). Handbook of batteries (4th ed.). McGraw-Hill.
2. Ibrahim, H., Ilinca, A., & Perron, J. (2008). Energy storage systems—Characteristics and comparisons. Renewable and Sustainable Energy Reviews, 12(5), 1221–1250.

Reference Books:

1. Chen, H., Cong, T. N., Yang, W., Tan, C., Li, Y., & Ding, Y. (2009). Progress in electrical energy storage system: A critical review. Progress in Natural Science, 19(3), 291–312.
2. Divya, K. C., & Østergaard, J. (2009). Battery energy storage technology for power systems—An overview. Electric Power Systems Research, 79(4), 511–520.
3. Dunn, B., Kamath, H., & Tarascon, J. M. (2011). Electrical energy storage for the grid: A battery of choices. Science, 334(6058), 928–935.

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B. Multidisciplinary Minor in "Electric Vehicle Systems"

Sem.	Course Code	Title
VII	EEMDM-05 B	AI and Cloud Computing in Electric Vehicles

Punyashlok Ahilyadevi Holkar Solapur University, Solapur
Final Year B. Tech. Electrical Engineering
Semester-I
(EEMDM-05B) AI and Cloud Computing in Electric Vehicles

Teaching Scheme	Examination Scheme
Theory: - 2 Hrs/Week, 2 Credits	**ESE**- 70 Marks
	ISE- 30 Marks

Course prerequisite:

Basic knowledge of computer usage, internet applications, and general science. No prior knowledge of electrical engineering, artificial intelligence, programming, or cloud computing is required.

Course Objectives

1. To introduce students to electric vehicle technology and its role in sustainable mobility.
2. To provide foundational understanding of Artificial Intelligence and its real-world applications.
3. To explain basic cloud computing concepts and connected vehicle systems.
4. To demonstrate practical applications of AI and cloud platforms in electric vehicle monitoring and management.
5. To develop awareness about smart mobility, digital transformation, and emerging transportation technologies.

Course Outcomes

After successful completion of the course, students will be able to:

1. Describe the basic structure and working principle of electric vehicles.
2. Explain fundamental concepts of Artificial Intelligence and data analytics.
3. Illustrate the role of cloud computing in connected vehicle ecosystems.
4. Discuss AI-based applications such as battery health prediction and smart navigation.
5. Examine the integration of IoT, AI, and cloud technologies in EV fleet and charging management.
6. Evaluate the impact of AI-driven electric mobility on sustainability, economy, and society.

SECTION-I

Unit I: Introduction to Electric Vehicles and Smart Mobility (5 Hours)

Evolution of transportation and the need for electric mobility. Environmental challenges and EV solutions. Basic components of an electric vehicle: Battery, motor, controller, and charging system.

Types of electric vehicles: Battery Electric Vehicles (BEVs), Hybrid Electric Vehicles (HEVs), Plug-in Hybrid Vehicles (PHEVs), and Fuel Cell Electric Vehicles (FCEVs). EV adoption trends and charging infrastructure. Concept of smart mobility in modern cities.

Unit II: Fundamentals of Artificial Intelligence (5 Hours)

Introduction to Artificial Intelligence (AI); basics of Machine Learning (ML); data-driven decision-making concepts; learning mechanisms in AI systems; applications of AI including recommendation systems, image recognition, and speech recognition; role of AI in transportation such as traffic prediction and intelligent navigation systems.

Unit III: Basics of Cloud Computing and IoT (5 Hours)

Introduction to cloud computing; cloud service models including Infrastructure as a Service (IAAS), Platform as a Service (PAAS), and Software as a Service (SAAS); cloud deployment models; data storage and remote processing in cloud systems; introduction to Internet of Things (IoT); integration of IoT with electric vehicles; applications including real-time data monitoring and remote diagnostics; basics of cyber security in cloud and IoT systems.

SECTION-II

Unit IV: AI Applications in Electric Vehicles (5 Hours)

AI-based battery management including state-of-charge (SoC) estimation and state-of-health (SoH) monitoring; energy optimization techniques; predictive maintenance using AI; driver behavior analysis; introduction to autonomous driving concepts; advanced driver assistance systems (ADAS); case studies of AI applications in EV industries.

Unit V: Cloud-Based EV Ecosystem and Fleet Management (5 Hours)

Cloud platforms for EV ecosystem; EV fleet tracking and management; charging station monitoring systems; route optimization using data analytics; over-the-air (OTA) software updates; smart charging systems; mobile applications for EV monitoring; vehicle-to-grid (V2G) technology; role of data analytics in improving operational efficiency and customer experience.

Unit VI: Future Trends, Sustainability, and Ethical Issues (5 Hours)

Connected vehicles and smart city integration; intelligent transportation systems (ITS); emerging technologies including digital twins, edge computing, and AI-based traffic management systems;

environmental impact of EV adoption; carbon footprint reduction strategies; sustainability goals in transportation; ethical issues including data privacy, cyber security, and AI bias in mobility systems.

Text Books:

1. Ehsani, M., Gao, Y., Longo, S., and Ebrahimi, K., *Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory and Design*, 3rd Edition, CRC Press, Boca Raton, 2018.
2. Buyya, R., Vecchiola, C., and Selvi, S.T., *Mastering Cloud Computing: Foundations and Applications Programming*, 1st Edition, Morgan Kaufmann, Burlington, 2013.
3. Husain, I., 2021. *Electric and hybrid vehicles: design fundamentals*. CRC press.

Reference Books:

1. Goodfellow, I., Bengio, Y., and Courville, A., *Deep Learning*, 1st Edition, MIT Press, Cambridge, 2016.
2. Larminie, J., and Lowry, J., *Electric Vehicle Technology Explained*, 2nd Edition, Wiley, Chichester, 2012.
3. Sarker, I.H., *Artificial Intelligence for Data Science*, 1st Edition, Springer, Cham, 2021.
4. Vasant, P., Zelinka, I., and Weber, G.W., *Intelligent Computing and Optimization for Smart Energy Systems*, 1st Edition, Springer, Cham, 2020.

A. Honors in "Electrical Vehicle"

Sem.	Course Code	Title
VII	EEHn-05 A	Mini Project

Punyashlok Ahilyadevi Holkar Solapur University, Solapur
Final Year B. Tech. Electrical Engineering
Semester-I
(EEHn-05A) Mini Project

Teaching Scheme	Examination Scheme
Practical: - 4 Hrs/Week, 2 Credit	**ICA-** 50 Marks

Course prerequisite:

Students shall have basic knowledge of electric vehicle technology, electric machines, power electronics, energy management systems, control systems, and familiarity with simulation tools (MATLAB/Simulink) and embedded systems (Arduino/Controllers) acquired from previous semesters.

Course Objectives

1. To provide students with hands-on experience in solving real-world problems related to Electric Vehicles and sustainable transportation systems.
2. To familiarize students with practical applications of EV systems including motors, battery management, charging infrastructure, and control strategies.
3. To enhance technical, analytical, and problem-solving skills through EV-based project development.
4. To develop project management, teamwork, documentation, and presentation skills.

Course Outcome: Upon successful completion of this course, a student should be able to:

1. Apply electrical engineering concepts to design and solve problems related to Electric Vehicles.
2. Demonstrate the ability to design, simulate, and implement EV subsystems such as motor drives, battery systems, and controllers.
3. Analyze and evaluate system performance based on efficiency, reliability, and sustainability.
4. Develop and present a comprehensive project report with proper technical documentation.
5. Gain exposure to emerging EV technologies and their industrial applications.

Guidelines for Mini Project on Electric Vehicle Applications

Students will form teams of 3–4 members and select a project topic related to Electric Vehicles. The project will follow a structured approach including problem identification, literature survey, system design, simulation/hardware implementation, testing, and validation. Each team will be guided by a faculty mentor. Students must maintain proper documentation, submit progress reports, and present their work through demonstrations, presentations, and viva. The project may involve hardware, software, or hybrid system development. A final hard copy of the project report shall be submitted upon successful completion of the project and maintained in the Institute records.

Domains for Mini Project on Electric Vehicle Applications (but not limited to the following)

1. **Electric Vehicle Powertrain:** Design and control of BLDC/PMSM motors, motor drives, and traction systems**.**
2. **Battery Management System (BMS):** State of Charge (SoC) estimation, cell balancing, battery protection systems.
3. **EV Charging Infrastructure:** Level-1, Level-2, and fast charging systems, wireless charging, smart charging stations.
4. **Energy Management in EV:** Optimization of energy usage, regenerative braking systems, hybrid energy storage.
5. **Power Electronics in EV:** DC-DC converters, inverters, and motor controllers for EV applications.
6. **Simulation of Electric/Hybrid Vehicles:** MATLAB/Simulink-based modeling of EV/HEV systems and performance analysis.
7. **IoT-based EV Monitoring Systems:** Real-time monitoring of battery, speed, and vehicle parameters using IoT.
8. **Sustainable Development Goals (SDGs):** Projects aligned with SDG 7 (Affordable and Clean Energy), SDG 9 (Industry, Innovation and Infrastructure), and SDG 13 (Climate Action).

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B. Honors in "Sustainable Power System"

Sem	Course Code	Title
VII	EEHn-05 B	Mini Project

	Punyashlok Ahilyadevi Holkar Solapur University, Solapur Final Year B. Tech. Electrical Engineering Semester-I (EEHn-05B) Mini Project

Teaching Scheme	Examination Scheme
Practical: - 4 Hrs/Week, 2 Credit	**ICA-** 50 Marks

Course Prerequisite:

Students shall have basic knowledge of renewable energy systems, power systems, smart grids, energy management systems, and familiarity with simulation tools (MATLAB/Simulink), AI basics, and electrical system modeling acquired from previous semesters.

Course Objectives:

1. To provide students with hands-on experience in solving real-world problems related to sustainable power systems and clean energy technologies.
2. To familiarize students with modern power system practices including renewable integration, smart grids, and AI-based energy management.
3. To enhance analytical, technical, and problem-solving skills through project-based learning.
4. To develop project management, documentation, and effective presentation skills.

Course Outcomes: After completing this course, students will be able to:

1. Apply electrical engineering principles to solve problems related to sustainable power systems.
2. Design and implement solutions for renewable energy integration and smart energy systems.
3. Analyze system performance considering technical, economic, and environmental aspects.
4. Develop and present a comprehensive project report with proper documentation.
5. Gain exposure to emerging technologies such as AI and smart grid applications in power systems.

Guidelines for Mini Project on Sustainable Power Systems:

Students will form teams of 3–4 members and select a project topic related to sustainable power systems. The project will follow a structured methodology including problem identification, literature review, system design, simulation/hardware implementation, testing, and validation. Each team will be guided by a faculty mentor. Students must maintain proper documentation, submit progress reports, and present their work through demonstrations, presentations, and viva. The project may include simulation, hardware implementation, or hybrid approaches. A final hard copy of the project report shall be submitted upon successful completion of the project and maintained in the Institute records.

Domains for Mini Project on Sustainable Power Systems (but not limited to the following):

1. **Renewable Energy Systems:** Solar PV systems, wind energy systems, hybrid renewable systems, and their performance analysis.
2. **Smart Energy Management Systems:** Demand-side management, load forecasting, smart metering, and energy optimization techniques.
3. **Distributed Energy Resources (DER) Integration:** Grid integration of distributed generation, micro grids, and decentralized energy systems.
4. **Smart Grid Technologies:** Advanced metering infrastructure (AMI), grid automation, and communication in power systems.
5. **AI Applications in Power Systems:** Load prediction, fault detection, predictive maintenance, and optimization using machine learning.
6. **Energy Storage Systems:** Battery energy storage systems (BESS), supercapacitors, and hybrid storage technologies.
7. **Power System Optimization:** Economic load dispatch, optimal power flow, and energy efficiency improvement techniques.
8. **Sustainable Development Goals (SDGs):** Projects aligned with SDG 7 (Affordable and Clean Energy), SDG 9 (Industry, Innovation and Infrastructure), and SDG 13 (Climate Action).

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SEMESTER -II

Punyashlok Ahilyadevi Holkar Solapur University, Solapur
Final Year B. Tech. Electrical Engineering
Semester-II
(EEPCC-15) ELECTRICAL ENERGY AUDIT AND MANAGEMENT

Teaching Scheme	**Examination Scheme**
Theory– 4 Hrs. /Week, 4 Credits	**ESE**-100 Marks

Course Prerequisite:

Basic understanding of energy sources and power generation systems, awareness of electricity tariffs and demand management concepts, and fundamental knowledge of electrical machines and power system operation.

Course Objectives

1. To explain the global and national energy scenario and the importance of energy conservation and energy security.
2. To describe the principles and organizational framework of energy management and energy policy implementation.
3. To analyze demand side and supply side energy management techniques in electrical power systems.
4. To examine the methodology, tools, and procedures used in electrical energy auditing.
5. To evaluate energy conservation opportunities in industrial and utility applications.
6. To assess the financial feasibility of energy conservation measures using economic analysis techniques.

Course Outcomes:

1. Explain the global and national energy scenario and its environmental implications.
2. Describe the principles, structure, and responsibilities involved in energy management.
3. Analyze demand side and supply side management techniques for efficient energy utilization.
4. Perform preliminary energy audits using standard tools, techniques, and data analysis methods.
5. Evaluate energy conservation measures in industrial and utility systems.
6. Assess the economic feasibility of energy efficiency projects using financial analysis techniques.

SECTION-I

Unit: 1 Energy Scenario and Energy Conservation Policies (08 Hrs.)

Classification of energy resources, commercial and non-commercial energy sources, conventional and renewable energy sources, global and Indian energy scenario, energy consumption trends, energy conservation and energy security, environmental impacts of energy use, emission standards, Energy Conservation Act 2001, Electricity Act 2003, overview of Energy Conservation Building Code (ECBC), and concept of green buildings, Introduction to Bureau of Energy Efficiency (BEE), BEE star labeling program, Perform Achieve and Trade (PAT) scheme, basic concepts of green energy systems such as solar and wind energy.

Unit 2: Energy Management Principles (08 Hrs)

Definition, objectives, and importance of energy management, principles and strategies of energy management, responsibilities of energy manager under Energy Conservation Act 2001, energy policy and organizational setup for energy management.

Energy monitoring systems, energy accounting, benchmarking, basics of SCADA and automatic meter reading (AMR). Introduction to Energy Management Systems (EnMS) and ISO 50001 concepts.

Unit 3: Demand Management (08 Hrs)

Supply Side Management (SSM): VAR compensation, system upgradation, distributed generation, and role of renewable energy systems.

Demand Side Management (DSM): objectives, advantages, barriers, and implementation techniques in domestic, agricultural, commercial, and industrial sectors. Demand management using Time of Day (TOD) tariff, power factor incentives and penalties. Role of solar PV, wind energy, biomass, and energy storage systems in energy management.

SECTION II

Unit 4: Energy Audit Methodology (08 Hrs)

Definition and need of energy audit, types of energy audits (preliminary and detailed), audit methodology and procedures, data collection and analysis techniques, energy audit instrumentation, Energy consumption – production relationship, pie charts. Sankey diagram, CUSUM technique, least square method and numerical based on it. Outcome of energy audit and energy saving potential, action plans for implementation of energy conservation options. Bench- marking energy performance of an industry. Preparation of energy audit reports and documentation standards. Audit case studies of sugar, steel, paper and cement industries.

Unit 5: Energy Conservation in Industrial Applications (08 Hrs)

Energy conservation in electrical systems including motors and drives, lighting systems, heating systems (boilers and steam systems), ventilation systems (fans, blowers and compressors), air conditioning and refrigeration systems, pumping systems, cogeneration and waste heat recovery, Utility industries (T and D Sector) diesel generator optimization, energy conservation practices in transmission and distribution systems. Basic energy conservation opportunities in solar PV and wind energy systems.

Unit 6: Financial Analysis of Energy Conservation Projects (08 Hrs)

Costing techniques and cost factors in energy management, budgeting and standard costing, sources of capital for energy efficiency projects, cash flow diagrams and activity charts, financial appraisal techniques including simple payback period, return on investment (ROI), net present value (NPV), time value of money, break-even analysis, sensitivity analysis, cost optimization, cost of energy and cost of generation, case studies related to industrial and utility energy conservation projects.

Text Books

1. Capehart, B. L., Turner, W. C., & Kennedy, W. J. (2020). *Guide to energy management* (9th ed.). CRC Press.
2. Kreith, F., & Goswami, D. Y. (2016). *Energy management and conservation handbook* (2nd ed.). CRC Press.
3. Smith, C. B. (2015). *Energy management principles* (2nd ed.). Elsevier.

Reference Books

1. Bureau of Energy Efficiency. (2015). *Energy manager training manual*. Bureau of Energy Efficiency, Government of India.
2. Eastop, T. D., & Croft, D. R. (2018). *Energy efficiency for engineers and technologists*. Longman Scientific & Technical.
3. Thumann, A., & Younger, W. J. (2017). *Handbook of energy audits* (9th ed.). Fairmont Press.
4. Witte, L. C., Schmidt, P. S., & Brown, D. R. (2018). *Industrial energy management and utilization*. CRC Press.

	Punyashlok Ahilyadevi Holkar Solapur University, Solapur **Final Year B. Tech. Electrical Engineering** **Semester-II** **(EEPEC – 05A) High Voltage Engineering**

Teaching Scheme	**Examination Scheme**
Theory– 4 Hrs. /Week, 4 Credits	**ESE**-100 Marks

Course Prerequisite:

The student shall know Electric Fields, Insulating materials, Dielectric materials, Dielectric strength of various insulating materials, Breakdown Phenomenon, Breakdown voltage, HVAC & HVDC transmission techniques.

Course Objectives

1. To study and apply electric field fundamentals to power systems & the surge voltage distribution.
2. To study various breakdown phenomena & evaluate practical considerations in gases.
3. To understand conduction & breakdown in liquids and solids dielectrics as well as compare between liquids & solids breakdown.
4. To understand the different techniques of high voltage and current measurement.
5. To explain the process of testing various electric apparatus.
6. To study the design of a high voltage laboratory with all safety measures.

Course Outcomes

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

1. Apply electric field fundamentals to the power system & analyze the surge voltage distribution.
2. Derive various breakdown phenomena & evaluate practical considerations in gases.
3. Describe conduction & breakdown in liquids and solid dielectrics.
4. Comprehend the different techniques of high voltage and current measurement.
5. Discuss the process of testing various electric apparatus
6. Illustrate the use of various tools and devices for design, sizing & ratings of high voltage laboratories.

SECTION-I

Unit 1: Electrostatic fields **(06 Hrs.)**

Electrostatic stresses, Gas/vacuum as insulators, Liquid breakdown, Solid breakdown, Estimation and control of electric stress, Surge voltages and their distribution and control.

Unit 2: Conduction and Breakdown in Gases **(10 Hrs.)**

Gases as insulating media, Ionization processes, Townsend's current growth equation, Current Growth in the presence of secondary processes, Townsend's criterion for breakdown, Paschen's law, Breakdown in non-uniform fields and corona discharges, Post-breakdown phenomena and applications, Practical considerations in using gases for insulation purposes.

Unit 3: Conduction and Breakdown in Liquid & Solid dielectric **(08 Hrs.)**

Liquids as insulators, Pure liquids and commercial liquids, Conduction and breakdown in pure liquids, Conduction and breakdown in commercial liquids, Intrinsic breakdown, Electromechanical breakdown, Thermal breakdown, Breakdowns of solid dielectrics in practice, Breakdown of composite dielectrics, Solid dielectrics used in practice.

SECTION-II

Unit 4: Generation & Measurement of high voltages and currents **(08 Hrs)**

Generation of HVDC/HVAC and impulse voltages, Generation of impulse currents, Tripping and control of impulse generators, Measurement of HVDC/HVAC and impulse voltages, Measurement of high DC, AC and impulse currents, CRO's for impulse voltage and current measurements.

Unit 5: High voltage testing of electrical apparatus **(08 Hrs.)**

Testing of insulators and bushings, testing of isolators and circuit breakers, testing of cables, testing of transformers, testing of surge diverters, Radio interference measurements.

Unit 6: Design, planning and layout of high voltage laboratories **(08 Hrs.)**

Test facilities provided in high voltage laboratories, Activities and studies in high voltage laboratories, Classification of high voltage laboratories, Size and ratings of high voltage laboratories, Grounding of impulse testing laboratories.

Textbooks:

1. Naidu, M. S., & Kamaraju, V. (2004). *High voltage engineering*. Tata McGraw-Hill Publishing Company Ltd.
2. Arora, R., & Mosch, W. (2011). *High voltage insulation engineering*. New Age International Publishers Ltd.
3. Wadhwa, C. L. (2010). *High voltage engineering*. New Age International Publishers Ltd.

Reference Books:

1. Kuffel, E., & Abdullah, M. (1970). *Introduction to high voltage engineering*. Pearson Education.
2. Kuffel, E., Zaengl, W. S., & Kuffel, J. (2000). *High voltage engineering fundamentals* (2nd ed.). Newnes Publications.
3. Razevig, D. V. (1993). *High voltage engineering* (M. P. Chourasia, Trans.). Khanna Publishers.

	Punyashlok Ahilyadevi Holkar Solapur University, Solapur **Final Year B. Tech. Electrical Engineering** **Semester-II** **(EEPEC – 05B) Instrumentation Process Control & Robotics**

Teaching Scheme	**Examination Scheme**
Theory– 4 Hrs. /Week, 4 Credits	**ESE**-100 Marks

Course Prerequisite:

Basic knowledge of mathematics, physics, electrical and electronic engineering fundamentals, control systems, and measurement principles is required for this course.

Course Objectives

1. To understand process control concepts including manipulated and disturbance variables.
2. To analyze the behavior and effects of various control actions (P, I, D, and PID).
3. To explain practical controller features such as auto-tuning, bumpless transfer, and integral windup.
4. To understand performance measures such as accuracy and repeatability in robotic systems.
5. To apply coordinate transformations and represent robotic systems using D-H parameters along with actuators and sensors.
6. To analyze direct and inverse kinematics and determine the workspace of serial manipulators.

Course Outcomes

After Completion of this Course, the Student will be able to

1. Define and explain control objectives, process variables, and process control loops.
2. Analyze responses of discontinuous and continuous control modes for standard inputs.
3. Apply standard tuning techniques to determine PID controller parameters.
4. Explain accuracy and repeatability concepts in robotic systems.
5. Apply transformations, D-H parameters, actuators, and sensors in robotic systems.
6. Analyze direct and inverse kinematics and determine the workspace of serial manipulators.

SECTION – I

Unit 1: Fundamentals of Process Control (08 Hours)

Elements of process control loop: control system evaluation, process variables, set point, controlled variable, manipulated variable, load variable. Representation of process loop components using standard symbols (basic control loops).Examples: temperature, flow, level, and pressure control loops.

Process characteristics: process equation, capacity, self-regulation, disturbances, control lag, process lag, and dead time (distance/velocity lag).

Unit 2: Controller Principles **(08 Hours)**

Control system parameters: error, variable range, cycling, direct/reverse action. Discontinuous control modes: two-position, multi-position, floating control. Continuous control modes: Proportional (P), Integral (I), Derivative (D), PI, PD, PID control. Practical aspects: reset windup, rate before reset, and bumpless transfer.

Unit 3: Tuning of Controllers **(08 Hours)**

Tuning criteria: quarter amplitude decay ratio, loop disturbance, optimum control, measure of quality, stability criteria. Tuning methods: Process reaction curve (open-loop method), Ziegler–Nichols method (closed-loop method), Frequency response method

SECTION – II

Unit 4: Robotics **(06 Hours)**

Robot anatomy and definition, Laws of robotics, history, and terminology. Performance measures: accuracy and repeatability.

Unit 5: Elements of Robots – Links, Joints, Actuators, and Sensors **(09 Hours)**

Position and orientation of rigid bodies. Homogeneous transformations. Representation of joints and links using D-H parameters. Examples of D-H parameter assignment and link transformations. Actuators: stepper motors, DC servo motors, brushless motors, and DC servo motor modeling. Transmissions: types and applications. Sensors: purpose, internal and external sensors. Common sensors: encoders, tachometers, strain gauge-based force/torque sensors, proximity sensors, distance sensors, and vision systems.

Unit 6: Kinematics of Serial Robots **(09 Hours)**

Introduction to robot kinematics. Direct and inverse kinematics problems. Kinematics of common serial manipulators. Workspace analysis of serial robots. Inverse kinematics of constrained and redundant robots. Tractrix-based approach for fixed and free robots and multi-body systems.

Text Books

1. Johnson, C. D., *Process Control and Instrumentation Technology*, Tata McGraw-Hill, 8th Ed.
2. Anderson, N. A., *Instrumentation for Process Measurement and Control*, CRC Press, 3rd Ed.

3. Coughanowr, D. R., *Process Systems Analysis and Control*, McGraw-Hill.
4. Harriott, P., *Process Control*, Tata McGraw-Hill.
5. Ghosal, A., *Robotics: Fundamental Concepts and Analysis*, Oxford University Press.
6. Fu, K. S., Gonzalez, R. C., & Lee, C. S. G., *Robotics*, McGraw-Hill.

Reference Books

1. Ogata, K., *Modern Control Engineering*, Prentice Hall.
2. Seborg, D. E. et al., *Process Dynamics and Control*, Wiley.
3. Smith, C. A. & Corripio, A. B., *Automatic Process Control*, Wiley.
4. Nise, N. S., *Control Systems Engineering*, Wiley.
5. Craig, J. J., *Introduction to Robotics: Mechanics and Control*, Pearson.

	Punyashlok Ahilyadevi Holkar Solapur University, Solapur **Final Year B. Tech. Electrical Engineering** **Semester-II** **(EEPEC – 05C) Advanced Applications in Solar Energy Technology**

Teaching Scheme	Examination Scheme
Theory– 4 Hrs. /Week, 4 Credits	**ESE**-100 Marks

Prerequisite:

Solar systems, the concept of cooling and heating, working of dryer and still systems

Course Objectives:

1. To understand advanced solar radiation principles and resource assessment.
2. To analyze modern photovoltaic technologies and their performance.
3. To study solar energy storage and hybrid systems.
4. To explore grid integration and smart solar applications.
5. To examine industrial, agricultural, and emerging solar applications.
6. To evaluate future trends and research directions in solar energy.

Course Outcome:

1. Explain solar radiation principles and perform solar resource assessment for different geographical locations.
2. Analyze and compare advanced solar photovoltaic technologies based on performance and efficiency parameters.
3. Utilize solar energy systems incorporating appropriate energy storage and hybrid configurations.
4. Apply grid-connected solar systems, including power electronic interfaces and smart grid integration.
5. Explore solar energy technologies for industrial, agricultural, and emerging real-world applications.
6. Assess modern trends, innovations, and sustainability aspects in solar energy systems.

SECTION – I

Unit 1: Solar Radiation & Resource Assessment (08 Hours)

Fundamentals of solar radiation and solar geometry. Physics of propagation of solar radiation from the sun to the earth. Sun–earth geometry and its significance. Measurement of solar radiation using instruments such as pyranometer and pyrheliometer. Estimation of solar radiation on horizontal and tilted surfaces. Effect of atmospheric conditions on solar radiation. Estimation of total solar radiation and resource assessment techniques.

Unit 2: Advanced Solar Photovoltaic Technologies (08 Hours)

Fundamentals and working principles of solar photovoltaic (PV) cells. Performance characteristics and analysis of PV cells, modules, and arrays. Standalone PV system design considerations. Advanced PV technologies including bifacial solar modules. Efficiency improvement techniques for PV systems.

Maximum Power Point Tracking (MPPT) techniques: Perturb and Observe (P&O) and Incremental Conductance methods. Components and design considerations of grid-connected PV systems. Solar power plant design and performance analysis.

Unit 3: Solar Energy Storage & Hybrid Systems (08 Hours)

Need for energy storage in solar energy systems. Classification of energy storage methods. Battery storage technologies: lithium-ion, lead-acid, and solid-state batteries. Thermal energy storage systems. Hydrogen energy storage and green hydrogen concepts.

Solar hybrid systems: Solar–wind hybrid and solar–diesel hybrid systems. Energy management and control strategies in hybrid systems.

SECTION – II

Unit 4: Grid Integration & Smart Solar Systems (08 Hours)

Grid-connected photovoltaic systems and their operation. Power electronics interfaces: inverters and converters. Grid synchronization techniques. Net metering concepts and relevant policies, Smart grid integration with solar energy systems. Role of IoT and artificial intelligence in solar applications. Power quality issues in grid-connected systems and mitigation techniques.

Unit 5: Industrial & Emerging Applications of Solar Energy (08 Hours)

Solar thermal systems for industrial process heating, Concentrated Solar Power (CSP) technologies. Solar desalination and water purification systems, Solar refrigeration and air conditioning systems. Applications in agriculture: solar pumps, dryers, and greenhouses, Solar-powered electric vehicle (EV) charging infrastructure.

Unit 6: Advanced & Future Trends in Solar Energy (08 Hours)

Building Integrated Photovoltaics (BIPV). Floating solar power plants. Space-based solar power concepts. Microgrids and rural electrification using solar energy. Application of artificial intelligence in solar forecasting and optimization. Environmental impact and sustainability considerations. Case studies of large-scale solar projects in India and across the globe.

Test Books

1. Duffie, J. A., & Beckman, W. A., *Solar Engineering of Thermal Processes*.
2. Solanki, C. S., *Solar Photovoltaics: Fundamentals and Applications*.
3. Twidell, J., & Weir, T., *Renewable Energy Resources*.
4. Sukhatme, S. P., & Nayak, J. K., *Solar Energy: Principles of Thermal Collection and Storage*.

Reference Books

1. Tiwari, G. N., *Solar Energy: Fundamentals, Design, Modeling and Applications*.
2. Sukhatme, S. P., & Nayak, J. K., *Solar Energy: Principles of Thermal Collection and Storage*.
3. Solanki, C. S., *Solar Photovoltaics: Fundamentals, Technologies and Applications*.
4. Duffie, J. A., & Beckman, W. A., *Solar Engineering of Thermal Processes*.
5. Garg, H. P., & Prakash, J., *Solar Energy: Fundamentals and Applications*.

	Punyashlok Ahilyadevi Holkar Solapur University, Solapur **Final Year B. Tech. Electrical Engineering** **Semester-II** **(EEPEC-05) MOOC**

Teaching Scheme	**Examination Scheme**
Theory– 4 Hrs. /Week, 4 Credits	**ESE-**100 Marks

Students can select & enroll for an approved minimum **twelve-week technical course** from various NPTEL/SWAYAM technical courses, or any other approved MOOC platform, complete its assignments, and appear for a certification examination conducted by NPTEL, SWAYAM, Or respective MOOC platform.

BOS Chairman / Coordinator will announce the list of approved NPTEL/MOOC online courses/areas of minimum twelve-week duration for 'Programme Elective Course-V' from the available NPTEL/SWAYAM/ MOOC courses and will make them available to students through the University website.

List of approved NPTEL/MOOC online courses/areas of minimum **twelve-week** duration based on the following areas

- Electric Vehicles
- Automation and Robotics
- Artificial intelligence
- Machine Learning and Deep Learning
- Sustainable Power System
- Advanced Power Electronic and Control
- Design of Photovoltaic system
- Advance Electrical Drives
- Embedded Systems for Electrical Applications
- Industrial Internet of Things (IIoT)
- Cyber Security in Power Systems
- Green Hydrogen and Energy Systems
- Digital Twin Technology for Power Systems
- AI Applications in Power Systems

Punyashlok Ahilyadevi Holkar Solapur University, Solapur
Final Year B. Tech. Electrical Engineering
Semester-II
(OJT) On-Job Training

Scheme	Examination Scheme
24 Hrs. /Week, 12 Credits	**ICA**-200 Marks
	OE- 100 Marks

Every student must undergo mandatory On Job Training (OJT) for a minimum duration of **03 months (90 days)** in an industry, organization, research institute, MSME, start up, consultancy, or relevant workplace related to the program of study. The OJT is intended to provide practical exposure, industrial experience, professional skills, and application of theoretical knowledge in real-world environments.

Objectives of OJT

1. To provide exposure to real industrial environments, work culture, and organizational practices related to the student’s specialization.
2. To apply theoretical and laboratory knowledge to real industrial problems.
3. To develop technical, analytical, and problem-solving skills through hands-on industrial training.
4. To enhance professional skills such as communication, teamwork, leadership, ethics, and discipline.
5. To familiarize students with modern industrial tools, technologies, standards, and safety practices.
6. To prepare students for employment and career readiness through practical exposure, industry interaction, and professional experience.

Outcomes of OJT: After successful completion of the On-Job Training, students will be able to:

1. Apply classroom and laboratory knowledge to real-world industrial practices and professional work environments.
2. Demonstrate proficiency in relevant tools, technologies, equipment, software, and methodologies related to their program specialization.
3. Apply professional ethics, discipline, and organizational practices in industrial work environments.
4. Analyze and solve workplace challenges using appropriate engineering principles and innovative approaches aligned with industry standards.
5. Develop professional communication and collaborative skills through technical discussions, documentation, and presentations.
6. Relate industrial training experiences with program outcomes and demonstrate preparedness for professional careers and higher responsibilities.

Guidelines for Students

1. The student should undergo OJT in a recognized industry/organization relevant to the program specialization, with prior approval from the department/institute.
2. Students must maintain regular attendance and discipline at the workplace as per the rules and regulations of the host organization.
3. The work carried out during OJT should focus on practical implementation, technical learning, innovation, real-world applications, and professional practices.
4. Each student/group shall work under the guidance of an internal faculty guide assigned by the department/Institute.
5. Students shall regularly communicate their progress and work updates to the faculty guide during the OJT period.
6. Students must facilitate and coordinate at least two visits of the faculty guide to the industry/organization for progress review and interaction with the industry mentor/supervisor.
7. Students shall ensure that the work carried out during OJT is relevant to the curriculum, program outcomes, and learning objectives of the course.
8. Students must submit the following documents at the completion of OJT:
    - OJT Completion Certificate from the organization/Industry
    - Industry Supervisor Evaluation/Feedback
    - Final OJT Report

Evaluation Scheme

The evaluation of OJT shall be based on:

1. Performance and conduct during training
2. Attendance and participation
3. Industry Supervisor Feedback
4. Quality of Final OJT Report
5. Presentation/Viva-Voce

Submission of Report

Students must submit a final OJT report in the prescribed format after successful completion of the training. The report shall include details of the organization, objectives, work carried out, technical learning outcomes, challenges faced, and conclusions. The submitted report shall be preserved by the institute as an official academic record.