Maharashtra State Board Of Technical Education, Mumbai

Learning and Assessment Scheme for Post S.S.C Diploma Courses

Programme Name	**: Diploma In Electrical Engineering**		
Programme Code	**: EE**	**With Effect From Academic Year**	**: 2023-24**
Duration Of Programme	**: 6 Semester**	**Duration**	**: 16 WEEKS**
Semester	**: Sixth** **NCrF Entry Level : 4.0**	**Scheme**	**: K**

Sr No	Course Title	Abbrevation	Course Type	Course Code	Total IKS Hrs for Sem.	Learning Scheme					Credits	Assessment Scheme											
						Actual Contact Hrs./Week			Self Learning (Activity/ Assignment /Micro Project)	Notional Learning Hrs /Week		Paper Duration (hrs.)	Theory				Based on LL & TL				Based on Self Learning		Total Marks
																	Practical						
						CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
													Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
(All Compulsory)																							
1	MANAGEMENT	MAN	AEC	315301	1	3	-	-	1	4	2	1.5	30	70*#	100	40	-	-	-	-	25	10	125
2	EMERGING TRENDS IN ELECTRICAL ENGINEERING	ETE	DSC	316326	-	4	-	-	-	4	2	1.5	30	70*#	100	40	-	-	-	-	-	-	100
3	ENERGY CONSERVATION AND AUDIT	ECA	DSC	316327	-	4	-	2	2	8	4	3	30	70	100	40	25	10	25#	10	25	10	175
4	MAINTENANCE OF ELECTRICAL EQUIPMENTS	MEE	DSC	316328	-	4	-	4	2	10	5	3	30	70	100	40	25	10	25#	10	25	10	175
5	BASIC PYTHON PROGRAMMING	BPP	AEC	313011	-	2	-	2	-	4	2	-	-	-	-	-	25	10	25@	10	-	-	50
6	CAPSTONE PROJECT	CPE	INP	316004	-	-	-	2	2	4	2	-	-	-	-	-	50	20	50#	20	50	20	150
Elective-II (Any - One)																							
7	INDUSTRIAL AUTOMATION	EIA	DSE	316329	-	3	-	2	1	6	3	3	30	70	100	40	25	10	25#	10	25	10	175
	INDUSTRIAL DRIVES AND CONTROL	IDC	DSE	316330	-	3	-	2	1	6	3	3	30	70	100	40	25	10	25#	10	25	10	175
	POWER SYSTEM ANALYSIS	PSA	DSE	316331	-	3	-	2	1	6	3	3	30	70	100	40	25	10	25#	10	25	10	175
Total					**1**	**20**		**12**	**8**		**20**		**150**	**350**	**500**		**150**		**150**		**150**		**950**

Sr No	Course Title	Abbrevation	Course Type	Course Code	Total IKS Hrs for Sem.	Learning Scheme					Credits	Assessment Scheme										
						Actual Contact Hrs./Week			Self Learning (Activity/ Assignment /Micro Project)	Notional Learning Hrs /Week		Paper Duration (hrs.)	Theory				Based on LL & TL				Based on Self Learning		Total Marks
																	Practical						
						CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
													Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	

Abbreviations : CL- Classroom Learning , TL- Tutorial Learning, LL-Laboratory Learning, FA - Formative Assessment,SA -Summative Assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment

Legends : @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination

Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

Course Category : Discipline Specific Course Core (DSC) , Discipline Specific Elective (DSE) , Value Education Course (VEC) , Intern./Apprenti./Project./Community (INP) , AbilityEnhancement Course (AEC) , Skill Enhancement Course (SEC) , GenericElective (GE)

Programme Name/s	: Architecture Assistantship/ Automobile Engineering./ Artificial Intelligence/ Agricultural Engineering/ Artificial Intelligence and Machine Learning/ Automation and Robotics/ Architecture/ Cloud Computing and Big Data/ Civil Engineering/ Chemical Engineering/ Computer Technology/ Computer Engineering/ Civil & Rural Engineering/ Construction Technology/ Computer Science & Engineering/ Fashion & Clothing Technology/ Digital Electronics/ Data Sciences/ Electrical Engineering/ Electronics & Tele-communication Engg./ Electrical and Electronics Engineering/ Electrical Power System/ Electronics & Communication Engg./ Electronics Engineering/ Food Technology/ Computer Hardware & Maintenance/ Instrumentation & Control/ Industrial Electronics/ Information Technology/ Computer Science & Information Technology/ Instrumentation/ Interior Design & Decoration/ Interior Design/ Civil & Environmental Engineering/ Mechanical Engineering/ Mechatronics/ Medical Laboratory Technology/ Medical Electronics/ Production Engineering/ Printing Technology/ Polymer Technology/ Surface Coating Technology/ Computer Science/ Textile Technology/ Electronics & Computer Engg.
Programme Code	: AA/ AE/ AI/ AL/ AN/ AO/ AT/ BD/ CE/ CH/ CM/ CO/ CR/ CS/ CW/ DC/ DE/ DS/ EE/ EJ/ EK/ EP/ ET/ EX/ FC/ HA/ IC/ IE/ IF/ IH/ IS/ IX/ IZ/ LE/ ME/ MK/ ML/ MU/ PG/ PN/ PO/ SC/ SE/ TC/ TE
Semester	: Fifth / Sixth
Course Title	: MANAGEMENT
Course Code	: 315301

I. RATIONALE

Effective management is the cornerstone of success for both organizations and individuals. It empowers diploma engineers/ professionals to accomplish their tasks with finesse and efficiency through strategic planning and thoughtful execution, projects can optimize finances, enhance safety measures, facilitate sound decision-making, foster team collaboration and cultivate a harmonious work environment. The diploma engineers require leadership and management skills with technical knowledge of the core field to carry out various tasks smoothly. This course aims to instill fundamental management techniques, empowering diploma engineers/ professionals to enhance their effectiveness in the workplace.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help the students to attain the following industry identified outcome through various teaching learning experiences: Apply the relevant managerial skills for achieving optimal results at workplace.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Use relevant management skills to handle work situation
- CO2 - Apply appropriate techniques of product, operations and project management
- CO3 - Use comprehensive tools of recent management practices
- CO4 - Plan suitable marketing strategy for a product / service
- CO5 - Utilize supply chain and human resource management techniques for effective management

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

MANAGEMENT **Course Code : 315301**

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
315301	MANAGEMENT	MAN	AEC	3	-	-	1	4	2	1.5	30	70*#	100	40	-	-	-	-	25	10	125

Total IKS Hrs for Sem. : 1 Hrs

Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment

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4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Justify the importance of management thoughts in Indian knowledge system. TLO 1.2 Describe the importance of management in day to day life. TLO 1.3 Explain Henry Fayol’s principles of management. TLO 1.4 Describe the role of each level of management in its management hierarchy. TLO 1.5 Practice the self management skills for a given situation TLO 1.6 Apply the required managerial skills for a given situation	**Unit - I Introduction to Management** 1.1 Evolution of management thoughts from ancient/medieval to modern times in India (IKS) 1.2 Management: meaning, importance, characteristics, functions & challenges. 1.3 Introduction to scientific management- Taylor's & Fayol's principles of management 1.4 Levels & functions of management at supervisory level. 1.5 Self management skills: Self awareness, self discipline, self motivation, goal setting, time management, decision making, stress management, work life balance and multitasking 1.6 Overview of Managerial Skills: negotiation skills, team management, conflict resolution, feedback, leadership	Presentations Case Study Interactive session Quiz competition Mixed Picture Puzzle

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
2	TLO 2.1 Identify the appropriate creativity technique for new product development TLO 2.2 Describe the new product development process for a product / service TLO 2.3 Comprehend the importance of various strategic steps Product Management TLO 2.4 Elaborate Agile product management TLO 2.5 Explain the significance of the Project Management TLO 2.6 Describe the various tools of project management	**Unit - II Product, Operations and Project Management** 2.1 Creativity and innovation management: creativity techniques - brainstorming, checklist, reverse brainstorming, morphological analysis, six thinking hats. 2.2 New product development, change management 2.3 Product Management -meaning, strategic steps for sustainable design of a product 2.4 Agile product management- concept, benefits, principles and manifesto 2.5 Project Management: importance, areas within project management,4Ps and phases 2.6 Tools of Project Management: PERT and CPM, GANTT & Chart Overview of Estimate and Budget	Presentations Case Study Video Demonstrations Presentations Role Play
3	TLO 3.1 Understand the importance of quality management tools TLO 3.2 Explain the importance of various techniques for optimization and waste minimization TLO 3.3 State the importance of ISO quality standards TLO 3.4 Describe ERP TLO 3.5 State the importance of ISO TLO 3.6 Recognize the importance of customer satisfaction as a competitive advantage	**Unit - III Management Practices** 3.1 Quality circle, kaizen, Six Sigma, TQM 3.2 5S, Kanban card system, TPM, Lean Manufacturing: Meaning, Steps and Importance 3.3 Quality Standards and ISO: Meaning, ISO 9001:2016, ISO 14000, OSHA 2020 3.4 The overview of ERP along with example 3.5 Service quality and customer/client satisfaction, servicescape	Presentation Case study Interactive session Quiz Video Demonstration Lecture Using Chalk-Board
4	TLO 4.1 Explain the importance of marketing techniques TLO 4.2 Explain the importance of needs, wants and desires in marketing TLO 4.3 Interpret the traditional and digital marketing techniques TLO 4.4 Plan different aspects of an event management	**Unit - IV Marketing Management** 4.1 Marketing management: meaning, significance, Seven P's of Marketing 4.2 Needs, wants and demands in marketing. Customer relationship management 4.3 Types of marketing: traditional and digital marketing 4.4 Event management: types, different aspects of event management, crisis management	Case Study Interactive session based video Role Play Flipped Classroom Presentations

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
5	TLO 5.1 State the importance of supply chain and logistics management TLO 5.2 Explain the components of supply chain and logistics Management TLO 5.3 Describe the role of information technology in supply chain & logistics management TLO 5.4 State the significance of Human Resource Management TLO 5.5 Analyze the various methods of recruitment, selection and training for an organization TLO 5.6 List the qualities of a successful supervisor	**Unit - V Supply Chain & Human Resource Management** 5.1 The overview of Supply Chain and logistics Management 5.2 Components of Supply Chain and logistics Management 5.3 Role of information technology in supply chain & logistics management 5.4 Overview of Human Resource Management-Meaning,significance,scope and principles 5.5 Recruitment, selection and training of human resources. Chalk Circle 5.6 Qualities of a successful supervisor /team leader and types of leadership	Presentations Video Demonstrations Case Study Collaborative learning Video Demonstrations Chalk-Board

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES : NOT APPLICABLE.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

Assignment / Article

- Make a one page note based on a book of management you read.
- Write a short article on inventory management exploring online learning resources.
- Prepare a report on ISO standards applicable to your field. a. IATF 16949-2016 / SLA-TS 16949-2016, - Automotive Industry b. ISO 22000 — Food safety management c. ISO 50001 — Energy management d. ISO/IEC 27001 - Cyber Security e. ISO/DIS 4931-1 - Buildings and civil engineering works
- Prepare a 4 quadrant matrix of time management for managing the tasks.
- Prepare a report on any one software used for Supply Chain and Logistics Management.
- Prepare a GANTT Chart for project management related to your field.

Note Taking

- Watch a Tedx Talk Video on managerial skills and take notes in the form of keywords.

Case Study

- Prepare a case study and discuss the same on following topics a.Self Management Skills b.Six Thinking Hats c.Kaizen d.Quality Circle e.Safety Measures in different organizations related to your field
- Study the recruitment and selection process of any organization related to your field.
- Prepare a case study on management lessons based on life of Chhatrapati Shivaji Maharaj
- Conduct outbound training on managerial skills. Make a video and upload on social media.

Quizes

- Participate in online quizzes related to areas of management .

Assignment

- Workshops to be conducted for students on following topics a. creativity techniques b. time management c. stress management d. negotiation and conflict e. goal setting f. meditation new product development

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED : NOT APPLICABLE

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Introduction to Management	CO1	13	8	6	4	18
2	II	Product, Operations and Project Management	CO2	8	2	4	6	12
3	III	Management Practices	CO3	8	4	4	6	14
4	IV	Marketing Management	CO4	8	2	4	6	12
5	V	Supply Chain & Human Resource Management	CO5	8	4	4	6	14
Grand Total				**45**	**20**	**22**	**28**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- MCQ Based Class Test, Self Learning Activities / Assignment

Summative Assessment (Assessment of Learning)

- Summative Assessment (Assessment of Learning) MCQ based

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3

CO1	1	1	1	-	-	2	3			
CO2	1	3	3	-	1	3	3			
CO3	1	3	1	-	1	1	3			
CO4	1	2	2	-	1	2	3			
CO5	1	1	2	-	1	2	3			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	A. K. Gupta	Engineering Management	S. Chand, ISBN: 81-219-2812-5, 2007, 2nd Edition
2	O. P. Khanna	Industrial Engineering &management	Dhanpat Rai Publication, ISBN: 978-8189928353, 2018
3	Harold Koontz and Heinz Weinrich	Essentials of Management	Tata McGraw Hill Education ISBN: 9789353168148, 2020, 12th edition
4	E. H. McGrath	Basic Managerial Skills for All	PHI ISBN: 978-8120343146, 2011, 9th Edition
5	Andrew DuBrin	Management Concepts and Cases	Cengage Learning, ISBN: 978-8131510537, 2009, 9th edition
6	K. Dennis Chambers	How Toyota Changed the World	Jaico Books ISBN: 978-81-8495-052-6, 2009
7	Jason D. O'Grandy	How Apple changed the Wolrd	Jaico Publishing House ISBN: 978-81-8495-052-0, 2009
8	Subhash Sharma	Indian Management	New Age International Private Limited ; ISBN-978-9389802412, 2020, 1st edition
9	Chitale, Dubey	Organizational Behaviour Text and Cases	PHI LEARNING PVT. LTD., ISBN: 978-9389347067, 2019, 2nd Edition

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://www.debonogroup.com/services/core-programs/six-thinking-hats/	Six Thinking Hats
2	https://hbr.org/1981/09/managing-human-resources	HR Management
3	https://theproductmanager.com/topics/agile-product-management/	Agile Product Management
4	https://www.cdlogistics.ca/freight-news/the-5-components-of-supply-chain-management	Supply Chain Management
5	https://www.infosectrain.com/blog/understanding-the-concepts-of-gantt-chart-and-critical-path-methodology-cpm	PERT, CPM, GANTT Chart
6	https://www.simplilearn.com/best-management-tools-article	Management Tools
7	https://www.psychometrica.in/free-online-psychometric-tests.html	Psychometric Tests
8	https://www.investopedia.com/terms/e/erp.asp	ERP
9	https://asq.org/quality-resources/quality-management-system	QMS
10	https://testlify.com/test-library/creative-thinking/	Psychometric Tests
11	https://www.mindtools.com/	Management Skills
12	https://www.investopedia.com/terms/d/digital-marketing.asp	Digital Marketing

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students

MANAGEMENT **Course Code : 315301**

MSBTE Approval Dt. 24/02/2025 **Semester - 5 / 6, K Scheme**

EMERGING TRENDS IN ELECTRICAL ENGINEERING **Course Code : 316326**

Programme Name/s	**: Electrical Engineering/ Electrical and Electronics Engineering/ Electrical Power System**
Programme Code	**: EE/ EK/ EP**
Semester	**: Sixth**
Course Title	**: EMERGING TRENDS IN ELECTRICAL ENGINEERING**
Course Code	**: 316326**

I. RATIONALE

Emerging technologies evolve rapidly in all the field of engineering and it is essential for technologists to stay updated on these aspects to face the day to day challenges in the industry as well as in the society. This course aims to prepare Diploma Engineers with insights into the emerging technological trends like smart systems, AI, intelligent motor controls and digitization.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help the student to attain the following Industry identified outcome through various teaching learning experiences: .

- **Acquire relevant knowledge of Emerging techniques in electrical engineering fields.**

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Suggest the relevant IoT technologies for electrical systems.
- CO2 - Elaborate the use relevant IoT and SCADA for Automation of electrical Grid systems.
- CO3 - Implement electrical engineering related emerging trends to develop smart city.
- CO4 - Suggest the relevant IMCC for the given application (s).
- CO5 - Select the relevant improved tariff and billing solution for the specified type of consumer.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
316326	EMERGING TRENDS IN ELECTRICAL ENGINEERING	ETE	DSC	4	-	-	-	4	2	1.5	30	70*#	100	40	-	-	-	-	-	-	100

Total IKS Hrs for Sem. : 0 Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

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7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Explain the specified Industrial Revolution with respect to the driving force behind it. TLO 1.2 Explain the Industrial Revolution 4.0 with respect to the specified component (s). TLO 1.3 Explain the changes in Industry 4.0 with respect to AIML and 5G. TLO 1.4 Explain the Importance of Industrial revolution 5.0. TLO 1.5 Explain the Principle and features of IoT. TLO 1.6 Apply the concepts of IoT in the given electrical systems.	**Unit - I Digitization beyond Automation** 1.1 Industrial Revolutions: Versions 1.0, 2.0, 3.0 and 4.0; the driving force for these revolutions. 1.2 Components of Industrial Revolution 4.0: Digitization, CPS (Cyber Physical Systems), IoT (Internet of Things), Cloud Computing and Cloud Manufacturing. 1.3 Role of 5G Communication, Machine learning (ML) and AI in Industry 4.0. 1.4 Industry Revolution 5.0: Introduction and Key Features. 1.5 IoT: Principle and features. 1.6 Applications of IoT in Industrial drives, Transmission System, Distribution System, Illumination system and Renewable energy.	Lecture Using Chalk-Board Video Demonstrations Flipped Classroom Presentations

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
2	TLO 2.1 Describe the smart grid with respect to the need, layout and its components. TLO 2.2 Explain the concept and formation of micro grid. TLO 2.3 Explain the given Distributed Generation technology(ies) in the power sector. TLO 2.4 Describe the role of Distributed Generation in the given Grid system. TLO 2.5 Use features of Automation System in smart substation. TLO 2.6 Identify specific application of IoT and SCADA for particular Grid.	**Unit - II Smart Grid** 2.1 Smart Grid: Need and evolution, layout and its components, advantages and barriers, Smart Grid projects in India. 2.2 Micro-Grid: Need and formation of Micro Grid. 2.3 Distributed Energy Resources: Distributed generation systems and distributed generation technologies. 2.4 Role of distributed generation in Smart Grid and Micro Grid. 2.5 Substation Automation System (SAS): Need, layout and components, salient features of substation automation. 2.6 IoT and SCADA application in Grid systems.	Lecture Using Chalk-Board Video Demonstrations Flipped Classroom Presentations Site/Industry Visit
3	TLO 3.1 Describe the smart city with respect to the needs, components and its challenges. TLO 3.2 Explain relevant technology associated with Metro/ EV. TLO 3.3 Compare various EV's based on the given criteria (s). TLO 3.4 Describe smart home on the basis of the given criteria (s). TLO 3.5 Implement the Renewable energy related policies in smart city.	**Unit - III Smart City (Electrical Features)** 3.1 Smart City: Features, components, objectives and challenges of smart cities in India. 3.2 Intercity Transportation: EV / Metro: Types, data-driven operations, automated train operation (ATO), autonomous driving technology, efficient charging infrastructure, wireless charging: opportunities and challenges. 3.3 Comparison between various types of Electric Vehicles: technology, type of motor, efficiency, batteries etc. 3.4 Smart Home: Features and components, role of AI powered illumination system and advancement in luminaries. smart appliance control principles (block diagram/s). 3.5 Renewable Energy: Role, opportunities, government policies: center / state.	Lecture Using Chalk-Board Video Demonstrations Flipped Classroom Presentations Site/Industry Visit

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
4	TLO 4.1 Describe the conventional MCC considering the given points. TLO 4.2 Explain the IMCC based on the given point (s). TLO 4.3 Describe advantages and limitations of modern MCCs including lack of networking and diagnostics. TLO 4.4 Describe the salient features of the given basic components of intelligent system. TLO 4.5 Describe the salient features of the given components and devices of IMCC. TLO 4.6 Compare intelligent and conventional MCC on the basis of the given criteria.	**Unit - IV Intelligent Motor Control Centers** 4.1 Conventional Motor Control Center (MCC): Role in motor protection and management, typical block diagram and architecture, components: symbols and functions. 4.2 Intelligent or Smart MCCs (IMCCs): Need and evolution from traditional MCCs. Functional block diagram and general arrangement, integration of industrial IoT (IIoT) and cloud-based real-time monitoring. 4.3 Applications, advantages and limitations in modern MCCs including lack of networking and diagnostics. 4.4 Basic Components of Intelligent Systems: Microprocessor / microcontroller-based control; networking technologies (Ethernet / IP, Modbus, PROFINET) replacing hard wiring, enhanced diagnostics, AI-based predictive maintenance, smart sensors, and edge computing for real-time diagnostics and wireless communication (Bluetooth, Zigbee) for remote control. 4.5 IMCC Components and Devices: Intelligent relays, digital fuses, cybersecurity features, dedicated software and advanced control devices. 4.6 Selection of MCC: Comparison between Intelligent and conventional MCC; Energy efficiency, cybersecurity, networking, and automation. Smart power management with power factor correction (PFC) and harmonic filtering for efficiency.	Lecture Using Chalk-Board Video Demonstrations Flipped Classroom Presentations Site/Industry Visit
5	TLO 5.1 Describe the given term(s) related to tariff economics. TLO 5.2 Explain the key factors required for the given type of tariff design. TLO 5.3 Explain the communication technologies used in the given type (s) of smart meters. TLO 5.4 State the relevant MERC rules applicable for Net-metering billing. TLO 5.5 Describe the use of deep learning model and communication methods in MRI / AMR.	**Unit - V Tariff and Smart Billing** 5.1 Tariff: Power purchase, Power purchase agreements (PPA), Power purchase cost. 5.2 Tariff Design: Key factors for tariff design, major components of an electricity bill, various slabs in billing, electricity duty, tax on electricity and cross subsidy. 5.3 Smart Metering: Components working principle, types of smart meters, features, communication technologies, advantages, challenges, role in Grid System. 5.4 Metering and Bill Management: Working of net metering and gross metering, MERC rules for net-metering bill (Latest Amendment), application of net metering for integration of micro-generators with grid system. 5.5 Meter reading techniques: use of deep learning model and communication methods in MRI / AMR.	Lecture Using Chalk-Board Video Demonstrations Flipped Classroom Presentations

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES : NOT APPLICABLE.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

Micro project

- Prepare a report on grid maintenance by using Drone
- Prepare a report on Role of 3D printer in Electrical Model design.

- Prepare a report on Flexible Electricity Billing System
- Prepare a report on Role of Smart CCTV in Smart City

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Not Applicable	All

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Digitization beyond Automation	CO1	12	6	6	2	14
2	II	Smart Grid	CO2	10	6	6	2	14
3	III	Smart City (Electrical Features)	CO3	12	4	6	4	14
4	IV	Intelligent Motor Control Centers	CO4	14	6	6	2	14
5	V	Tariff and Smart Billing	CO5	12	6	6	2	14
Grand Total				**60**	**28**	**30**	**12**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Formative assessment (Assessment for Learning) Two unit tests of 30 marks will be conducted and average of two unit tests considered.

Summative Assessment (Assessment of Learning)

- End semester assessment of 70 marks through Online mode of examination.

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	3	1	2	1	2	1	1			
CO2	3	1	2	1	2	1	1			
CO3	3	1	2	2	2	2	2			
CO4	3	1	2	2	1	1	1			
CO5	3	1	1	1	1	1	1			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	S K Bhattacharya	Control of Electrical Machines	New Age International ISBN13: 8122409970, 9788122409970
2	Akihiko Yokoyama	Smart Grid: Fundamentals, Design, Technology, Applications, Communication and Security, An Indian Adaptation	Wiley, 1 April 2021 Edition ISBN-13: 978-9354243219
3	Frank D. Petruzella	Electrical Motor Control Systems	McGraw-Hill College, 22 November 2019, ISBN-13: 978-1260439397
4	Merizalde	Encyclopaedia of Applied Intelligent Control of Induction Motor Drives	Auris Reference (1 April 2018) ISBN-13: 978-1788022651
5	P K Pandey	IOT (Internet of things) and Its Application	T Balaji Publication (1 January 2020) ISBN 13:978-8194136385
6	Pandian Vasant	Artificial Intelligence in Industry 4.0 and 5G Technology	Wiley 30 June 2022 ISBN-13: 978-1119798767

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	41.-30.12.2019-Grid-Interactive-RRE-Regulations2019-English. pdf	MERC rules for net-metering bill
2	https://youtu.be/Xpb9XKmRsyw?si=0oLY-lKVyvPWiBSE	History of Industrial Revolution
3	https://www.geeksforgeeks.org/introduction-to-internet-of-things-iot-set-1/	Introduction to Internet of Things (IoT)
4	https://www.researchgate.net/publication/321529309_Sustainable_Smart_Cities_in_India_Challenges_and_Future_Perspectives	Sustainable Smart Cities in India: Challenges and Future Perspectives
5	https://www.iea.org/energy-system/electricity/smart-grids	Electricity smart grid
6	https://electricalengineerpro.com/latest-trends-in-electrical-engineering/	Trends in Electrical Engineering
7	https://www.youtube.com/watch?v=MTqML_JCpsY	Intelligence motor control system for engineers (Hindi)

EMERGING TRENDS IN ELECTRICAL ENGINEERING **Course Code : 316326**

Sr.No	Link / Portal	Description
8	https://www.youtube.com/watch?v=IEsmG83IxLs	IMCC Drawing, IMCC RDOL Drawing, IMCC Panel drawing, IMCC PRO V DRAWING, IMCC Simocode drawing

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students

ENERGY CONSERVATION AND AUDIT **Course Code : 316327**

Programme Name/s : **Electrical Engineering/ Electrical Power System**

Programme Code : **EE/ EP**

Semester : **Sixth**

Course Title : **ENERGY CONSERVATION AND AUDIT**

Course Code : **316327**

I. RATIONALE

Due to rapid industrialization, urbanization, and population growth, the world is experiencing an increasing demand for electrical energy. The fossil fuels prime source for generation of electrical energy are depleting at faster rate. One unit of saving of electricity is equivalent to two units of electricity generated. Hence conserving energy is responsibility of every citizen. This curriculum enables the diploma students with the skill sets of carrying out energy audit and conserve electrical energy in electrical systems.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help the student to attain the following industry-identified competency through various teaching-learning experiences :

- **Implement energy-saving measures and conduct comprehensive energy audits.**

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Interpret energy conservation policies in India.
- CO2 - Implement energy conservation techniques in electrical machines.
- CO3 - Apply energy conservation techniques in electrical installations.
- CO4 - Use Co-generation and relevant tariff for reducing losses in facilities.
- CO5 - Carryout energy audit for electrical system.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
316327	ENERGY CONSERVATION AND AUDIT	ECA	DSC	4	-	2	2	8	4	3	30	70	100	40	25	10	25#	10	25	10	175

Total IKS Hrs for Sem. : 0 Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Present the current scenario of conventional and non-conventional energy sources in India. TLO 1.2 Differentiate between energy management, energy efficiency, energy conservation and energy audit. TLO 1.3 Explain the salient features of Energy conservation act 2001. TLO 1.4 Describe the role of BEE, MEDA and MNRE. TLO 1.5 Interpret the Star Labeling of the given electrical equipment. TLO 1.6 Explain the Concept of energy conservation and its benefits. TLO 1.7 Describe the key features of ECBC and green buildings.	**Unit - I Fundamentals of Energy Conservation and Management** 1.1 Energy Scenario: Primary and secondary energy sources, energy demand and supply at National level. 1.2 Energy management, energy efficiency, energy conservation and energy audit: Objectives, concepts and difference. 1.3 Energy Conservation Act 2001 with latest amendments: Key provisions and relevant clauses. 1.4 Role of: Bureau of Energy Efficiency (BEE), Maharashtra Energy Development Agency (MEDA) and Ministry of New and Renewable Energy (MNRE). 1.5 Star labeling: Need, significance and benefits. 1.6 Concept of energy conservation and benefits. 1.7 Energy Conservation Building Codes (ECBC) with latest revision, concept of green buildings.	Lecture Using Chalk-Board Flipped Classroom Video Demonstrations Case Study Presentations

ENERGY CONSERVATION AND AUDIT **Course Code : 316327**

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
2	TLO 2.1 Justify the need and significance of energy conservation in induction motor and transformer. TLO 2.2 Enlist the energy conservation techniques for a given three phase induction motor. TLO 2.3 Describe the energy conservation techniques for a given Transformer. TLO 2.4 Describe the key features and working of a given energy conservation equipment. TLO 2.5 Compare energy efficient motor with standard motor. TLO 2.6 Compare energy efficient transformer with standard transformer. TLO 2.7 State the energy conservation strategies in compressors pumps, fans and blowers.	**Unit - II Energy Conservation in Electrical Machines** 2.1 Need and significance of energy conservation in induction motor and transformer. 2.2 Energy conservation techniques in induction motor by: Improving power quality, motor survey, matching motor with loading, minimizing the idle and redundant running of motor, operating in star mode, rewinding of motor, replacement by energy efficient motor, periodic maintenance, by using sensor based motors. 2.3 Energy conservation techniques in transformer: Load sharing, parallel operation, isolating techniques, replacement by energy efficient transformers, periodic maintenance. 2.4 Energy conservation equipment- key features and working of: Soft starters, Automatic star delta convertor, Variable Frequency Drives (VFD). 2.5 Energy efficient motor: Key features, merits, demerits, comparison with standard motor. 2.6 Energy efficient transformers: Amorphous transformers, epoxy resin-cast transformer and dry-type of transformer. 2.7 Methods and techniques of energy conservation in compressors pumps, fans and blowers.	Lecture Using Chalk-Board Flipped Classroom Video Demonstrations Case Study Site/Industry Visit
3	TLO 3.1 Interpret losses in the given power system. TLO 3.2 Explain the method to reduce the specified technical loss in the given electrical installation. TLO 3.3 Explain the method to reduce the specified commercial loss in the given electrical installation. TLO 3.4 Select the relevant energy conservation equipment for the given system with justification. TLO 3.5 Explain energy conservation measures for the specified lighting installation. TLO 3.6 State the energy conservation strategies in fan and regulator. TLO 3.7 Describe energy conservation techniques in EVs and batteries.	**Unit - III Energy conservation in Electrical Installation system** 3.1 Aggregate technical and commercial losses (ATC). 3.2 Technical losses: Causes and remedies-Controlling copper losses, optimizing distribution voltage, balancing phase currents, compensating reactive power flow. 3.3 Commercial losses: Causes and remedies. 3.4 Energy conservation equipment: Maximum Demand Controller, kVAR Controller, Capacitor bank, Automatic Power Factor controller (APFC), Intelligent Power Factor Controller (IPFC) and Active Harmonic Filters (AHF). 3.5 Energy Conservation in Lighting systems: Replacing Lamp sources, using energy efficient luminaries, using light controlled gears, Installation of separate transformer / servo stabilizer for lighting, use of sensors- motion, occupancy, proximity, color, photo sensitive sensors, Periodic survey and adequate maintenance programs. 3.6 Energy conservation techniques in fans, electronic regulators using solid state devices. 3.7 Energy conservation techniques in electric vehicles and batteries.	Lecture Using Chalk-Board Flipped Classroom Case Study Video Demonstrations Site/Industry Visit

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
4	TLO 4.1 Enumerate the factors governing the selection of co-generation system. TLO 4.2 Describe suitable type of co-generation system for the given facility. TLO 4.3 Describe the function of combined heat and power (CHP) system in the given facility. TLO 4.4 Explain a given type of tariff structure. TLO 4.5 Describe the suitable tariff system for reducing the electricity bill of a given facility. TLO 4.6 Compare two different tariff structure illustrating electrical energy conserved in a given facility.	**Unit - IV Energy Conservation via Cogeneration and Tariff** 4.1 Co-generation: Concept, factors governing the selection of co-generation system and its advantages. 4.2 Types of co-generation: Based on sequence of energy use: Topping cycle, Bottoming cycle, Based on technology: Steam turbine, Gas turbine and Reciprocating engine co-generation. 4.3 Captive Power Plant: Combined Heat and Power (CHP) system. 4.4 Tariff: Concept from the point of view of energy conservation, Types of tariff structure: LT, HT, Special, Time-off-day, Peak-off-day, Power factor tariff, Maximum Demand tariff, Load factor tariff and Availability Based Tariff (ABT), kVAh tariff, Concept of flexible tariff. 4.5 Application of tariff system to reduce energy bill (Numerical). 4.6 Recent tariff structure of different utilities.	Lecture Using Chalk-Board Flipped Classroom Video Demonstrations Case Study Site/Industry Visit
5	TLO 5.1 Define energy audit and list the benefits. TLO 5.2 Justify significance of specific energy consumption. TLO 5.3 Explain the types of energy audit. TLO 5.4 Suggest relevant instrument (s) for the specified energy audit with justification. TLO 5.5 Develop questionnaire for the energy audit of the given facility. TLO 5.6 Develop the energy flow diagram of the given facility/ apparatus. TLO 5.7 Calculate the Simple Pay Back period, IRR for the facility created. TLO 5.8 Describe energy audit procedure followed. TLO 5.9 Prepare the energy audit report for the given facility/ apparatus. TLO 5.10 Describe the roles and responsibilities of energy manager and auditor.	**Unit - V Energy Audit** 5.1 Energy audit: Definition and its benefits. 5.2 Significance of Specific energy consumption pattern. 5.3 Types of energy audit: Walk through and detailed audit. 5.4 Energy audit instruments and their use: Electrical measuring instruments, power analyzer, lux meter, smart energy meter, fuel efficiency monitor, combustion gas analyzer, thermometer, flow meter and tachometer. 5.5 Questionnaire for energy audit projects. 5.6 Energy flow diagram (Sankey diagram). 5.7 Simple payback period, Internal Rate of Return (IRR) (Numerical). 5.8 Energy Audit procedure. 5.9 Typical Energy Audit report format commonly used in industries. 5.10 Roles and responsibilities of energy manager and auditor.	Lecture Using Chalk-Board Flipped Classroom Video Demonstrations Case Study Site/Industry Visit

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Identify star labelled appliances and compare them for various star ratings. LLO 1.2 Compare the data sheet of various star rating appliances.	1	*Identification of star labelled electrical appliances/equipment and compare data sheets of various star labelled ratings.	2	CO1
LLO 2.1 Compare energy consumed by a green building with that of a conventional building. LLO 2.2 Use energy conservation instruments to measure the various electrical parameters.	2	Comparison of energy consumption in a green building with a conventional building using energy conservation instruments.	2	CO1
LLO 3.1 Perform an experiment on three phase induction motor both in star and delta mode. LLO 3.2 Measure the effect of voltage reduction in power consumption.	3	*Determination of reduction in power consumption in star mode operation of 3 phase Induction motor compared to delta mode.	2	CO2
LLO 4.1 Perform load test on three phase induction motor for different loading conditions. LLO 4.2 Plot the graph of efficiency verses percentage loading of induction motor.	4	*Performance of load test on three phase induction motor for different loading conditions and plot the curve.	2	CO2
LLO 5.1 Compare energy conserved in two identical transformers where one is a single-phase transformer, and the other one comprises of two single phase transformers in parallel operation (For the same load). LLO 5.2 Observe the effect of load sharing on energy consumption.	5	Comparison of energy conserved in two identical transformers where one is a single-phase transformer and the other one comprises of two single phase transformers in parallel operation. (For the same load).	2	CO2
LLO 6.1 Improve power factor of given load using APFC. LLO 6.2 Using APFC for improving power factor.	6	Power factor improvement using APFC.	2	CO2 CO3
LLO 7.1 Improve power factor of given load using static capacitor. LLO 7.2 Calculate the value of capacitor to change from initial power factor to desired power factor.	7	*Power factor improvement using static capacitor.	2	CO2 CO3
LLO 8.1 Improve power factor of given load using IPFC. LLO 8.2 Using IPFC for improving power factor.	8	Power factor improvement using IPFC.	2	CO2 CO3
LLO 9.1 Compare power consumption of different types of Tube Light with choke, electronic ballast and LED lamps by direct measurement.	9	*Comparison of power consumption of different types of Tube Light with choke, electronic ballast and LED lamps by direct measurement.	2	CO3
LLO 10.1 Determine the reduction in power consumption by replacement of different lamps in a classroom / laboratory by energy efficient lamps.	10	*Comparison of reduction in power by replacement of lamps in a classroom / laboratory by energy efficient lamps.	2	CO3

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 11.1 Suggest suitable tariff for energy conservation and reduction of energy bill for an industrial customer. LLO 11.2 Interpreting electricity bill of an industrial consumer.	11	Tariff for industrial consumer for reducing the electricity bill.	2	CO4
LLO 12.1 Suggest suitable tariff for energy conservation and reduction of energy bill for a commercial customer. LLO 12.2 Interpreting electricity bill of a commercial customer.	12	Tariff for commercial consumer for reducing the electricity bill.	2	CO4
LLO 13.1 Suggest suitable tariff for energy conservation and reduction of energy bill for a residential customer. LLO 13.2 Interpreting electricity bill of a residential customer.	13	*Tariff for residential consumer for reducing the electricity bill.	2	CO4
LLO 14.1 Estimate energy saving by improving power factor and load factor for given case.	14	Estimation of Energy saved by improving power factor and load factor for given case.	2	CO3 CO4
LLO 15.1 Prepare a sample energy audit questionnaire for a given facility.	15	Preparation of Energy audit questionnaire for the given facility.	2	CO5
LLO 16.1 Prepare energy audit report of your electrical department.	16	*Preparation of Energy audit report of electrical department.	2	CO5
LLO 17.1 Perform load test on three phase SCIM using DOL, star delta and soft starter. LLO 17.2 Compare the energy consumption in all three cases.	17	Comparison of energy consumption using DOL, star delta and soft starter in a three-phase induction motor.	2	CO2
LLO 18.1 Carryout energy audit using energy audit software such as SafetyCulture (formally iAuditor) or EnergyCAP. LLO 18.2 Use energy audit software SafetyCulture (formally iAuditor) or EnergyCAP.	18	Energy audit using energy audit software such as SafetyCulture (formally iAuditor), EnergyCAP or any other equivalent software.	2	CO5

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

Micro project

- Collect electricity bill of your institute and suggest suitable measures for energy conservation and reduction of energy bill.
- Prepare Energy conservation chart using different luminaries.
- Prepare an energy audit report of your department/Institute/Workshop using energy audit instruments.
- Visit MEDA website and enlist various energy conservation schemes. Prepare a presentation highlighting the salient features of any one scheme. (objectives, entitlement, methodology and financial assistance etc.)
- Carry out a case study of at least two nearby industries and prepare a report on energy conservation measures adopted by them.

- Carry out internet survey (BEE) to collect information and prepare a report related to any two energy conservation projects.
- Poster preparation and competition on energy conservation (Visit MEDA website).

Assignment

- Visit a facility adopting cogeneration system and prepare a presentation.
- Estimate the payback period, depreciation cost, for the given energy saving equipment in the transmission and distribution system.
- Prepare a report on maintenance procedure followed for improving efficiency of a given lighting scheme.
- Collect information about energy efficient luminaries and prepare a report on it.
- Write report on performance of motor after rewinding.
- Compile the energy saved in at least five star labeled various appliances and prepare a report.
- Prepare a report on various star labeled equipment.
- Compare the energy conserved by an energy efficient motor with a standard motor and prepare a report.
- Prepare a report on BIS standards related to Energy Conservation

Seminar topics

- Energy conservation act 2001.
- Energy conservation equipment
- Cogeneration and its advantages in energy conservation.
- “Bachat Lamp Yojana” Scheme.
- Energy Audit instruments and their working.
- Energy conservation schemes of Maharashtra.

Visit

- Visit to your nearby market/shop for Identifying star labeled electrical apparatus and compare the data for various star ratings. Prepare a chart and submit the report.
- Visit nearby industry which has a captive power plant and observe the working of Captive power plant its inputs and outputs. Prepare a report and submit with the main focus on energy saved due to captive power plant.

Self-learning topics

- Captive Power Plant
- Demand side management.
- Green buildings.
- Energy conservation initiatives in Agricultural sector.

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Lux meter	15,16

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
2	Soft starter/ DOL starter/ star delta starter.	17
3	Energy audit software such as SafetyCulture (formally iAuditor), EnergyCAP or any other equivalent open-source software.	18
4	Star delta convertor.	3
5	Induction motor: Single phase/three phase.	3,4
6	Clamp on ammeter.	3,4,5,7,9
7	Ammeter: MI type, AC/ DC 0-5-10Amp.	3,4,5,7,9
8	Voltmeter: MI type, AC/DC, 0-150/300V, 0-250/500V.	3,4,5,7,9
9	Wattmeter: Single phase/three phase, single element/double element, 2.5/5Amp -5/10 Amp, 200/400V -250/500V.	3,4,5,7,9,10,17
10	Multi-function meter.	3,4,5,7,9,10,17
11	Single/ three phase power factor meters: AC, 415V, 50 Hz, 5-10 Amp.	4,7
12	Transformer: Single phase.	5
13	Automatic power factor controller.	6
14	Low power factor wattmeter: Single phase, 5/10Amp, 250/500V.	6,8
15	Load bank.	7
16	Single phase capacitor bank.	7
17	Electronic choke, electronics ballast.	7,9
18	Intelligent power factor controller.	8
19	LED lamp/ tube.	9
20	Tube light (Fluorescent Tube/ CFL)	9

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Fundamentals of Energy Conservation and Management	CO1	8	2	2	4	8
2	II	Energy Conservation in Electrical Machines	CO2	14	4	4	6	14
3	III	Energy conservation in Electrical Installation system	CO3	14	2	6	8	16
4	IV	Energy Conservation via Cogeneration and Tariff	CO4	14	4	4	8	16
5	V	Energy Audit	CO5	10	2	6	8	16
Grand Total				**60**	**14**	**22**	**34**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Two unit tests, each worth 30 marks, will be conducted, and the average of the two tests will be considered.
- For formative assessment of laboratory learning 25 marks: Each practical will be assessed considering appropriate % weightage to process and product and other instructions of assessment. and the average of all practical will be considered.

Summative Assessment (Assessment of Learning)

- End semester summative assessment of 25 marks for laboratory learning.
- End semester assessment of 70 marks through offline mode of examination.

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	3	1	1	-	2	-	3			
CO2	3	2	2	1	2	1	3			
CO3	3	3	3	2	2	1	3			
CO4	3	3	3	2	2	1	3			
CO5	3	3	3	3	2	3	3			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Bureau of Energy Efficiency (BEE)	Guidebooks no. 1 to 4 for National Certification Examination for Energy Managers and Energy Auditors	Bureau of Energy Efficiency (A Statutory body under Ministry of Power, Government of India) (Fourth Edition 2015)
2	Dr. Sanjeev Singh, Dr. Umesh Rathore	Energy Management	S K Kataria & Sons, New Delhi. ISBN-13: 9789350141014
3	V.K.Mehta and Rohit Mehta	Principles of Power System	S. Chand & Co. New Delhi, 2022, ISBN: 9789355010773
4	Anil Kumar, Om Prakash, Prashant Singh Chauhan, Samsher Gautam	Energy Management Conservation and Audits	CRC Press, 2020, ISBN: 9780429325458
5	Stephan A. Roosa, Steve Doty, Wayne C. Turner	Energy Management Handbook	Fairmount Press, New York 2020 ISBN: 9781003151364
6	Murphy W.R.	Energy Management	Butterworth-Heinemann Publication, ISBN: 9788131207383.
7	K.V. Sharma, P. Venkataseshaiah.	Energy Management and Conservation	I K International Publishing House Pvt. Ltd; 2011 ISBN 9789381141298
8	Yogendra V. Talware.	Art of reading Electricity bills.	Dnyatavya Prakashan

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://mnre.gov.in/	Information about new and renewable energy.
2	https://powermin.gov.in/	Indian power scenario.
3	https://aipnpc.org/Guidebooks.aspx	BEE guidebooks 01 to 04.
4	https://akshayurja.gov.in/res/renw-all-india-cp	Akshay Urja Ministry of New and Renewable Energy (MNRE)
5	https://www.mahaurja.com/meda/en/energy_conservation/energy_conservation_program	Energy Conservation Schemes in Maharashtra state (MEDA)

Sr.No	Link / Portal	Description
6	https://www.eia.gov/totalenergy/	U S Energy information administration.
7	https://beeindia.gov.in/sites/default/files/ECBC%20User%20Guide%20V-0.2%20(Public).pdf	Energy Conservation Building Code User Guide.
8	https://iiec.org/	International Institute for Energy Conservation (IIEC)
9	https://cea.nic.in/	Central Electricity Authority

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students

MAINTENANCE OF ELECTRICAL EQUIPMENTS **Course Code : 316328**

Programme Name/s : **Electrical Engineering/ Electrical Power System**
Programme Code : **EE/ EP**
Semester : **Sixth**
Course Title : **MAINTENANCE OF ELECTRICAL EQUIPMENTS**
Course Code : **316328**

I. RATIONALE

The electrical engineering technologist is required to carry out the maintenance of the electrical machines and equipment, which includes installation, testing and commissioning. S/he is thus expected to use the relevant skill sets while working in the industry, commercial establishments, and public utility departments such as PWD, irrigation, electricity supply agencies, water supply and sewage board etc. This course aims the students with the skills to inspect various types of installations and test electrical machines as per prevailing standard practices. S/he will also be able to carry out maintenance activities of different types of electrical equipment. S/he will follow the relevant safety practices during such activities.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences: Maintain different types of electrical equipment following safe practices.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Follow safety norms to prevent accidents while using electrical equipment.
- CO2 - Test electrical equipment.
- CO3 - Maintain rotating electrical machines.
- CO4 - Maintain single phase and three phase transformers.
- CO5 - Maintain insulation systems of electrical equipment.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
316328	MAINTENANCE OF ELECTRICAL EQUIPMENTS	MEE	DSC	4	-	4	2	10	5	3	30	70	100	40	25	10	25#	10	25	10	175

Total IKS Hrs for Sem. : 0 Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Explain the hazards, safety actions for the given situation. TLO 1.2 Explain the importance of accident prevention. TLO 1.3 Describe the responsibilities and the monitoring actions of the supervisor in the given hazardous or accident situation. TLO 1.4 Describe the operating procedural steps of the given types of fire extinguishers. TLO 1.5 State the principal characteristics and related precautions for safety of equipment earthed by the specified clause. TLO 1.6 State the reasons behind failure of the given electrical equipment. TLO 1.7 State the role of Bureau of Indian Standards in testing, importance of ISI mark in testing and maintenance of electrical equipment.	**Unit - I Safety and prevention of accidents** 1.1 Hazards, accidents, safety 1.2 Dos and Don’ts for electrical supervisors. 1.3 Electric shock: factors influencing severity of shock, rescuing a person from electric shock, different CPR Technique to employed under accidental condition. 1.4 Artificial respiration: types & procedures. 1.5 Precautions against electric fire. 1.6 Types of fire extinguishers, “PASS” & “RACE” in case of fire. 1.7 Objectives of earthing. Earthing of electrical equipment as per IS 3043-1987 1.8 Protection of electrical equipment against electric shock (class 0 to class III). 1.9 Causes of failure of electrical Equipment: internal and external 1.10 Role of BIS in testing of electrical Equipment.	Lecture Using Chalk-Board Model Demonstration Video Demonstrations Case Study Collaborative learning Hands-on Site/Industry Visit

MAINTENANCE OF ELECTRICAL EQUIPMENTS **Course Code : 316328**

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
2	TLO 2.1 Explain the objectives of the testing. TLO 2.2 Describe the procedure of the given testing methods. TLO 2.3 Explain the importance of the given categories of tests. TLO 2.4 Explain the importance of tolerance. TLO 2.5 Explain meaning and importance of ingress protection. TLO 2.6 Explain significance of maintenance of electrical equipment. TLO 2.7 State the given type(s) of maintenance technique. TLO 2.8 Explain the given factor(s) affecting preventive maintenance. TLO 2.9 Describe the procedures for developing preventive maintenance schedule. TLO 2.10 Explain the steps in preparing foundation for the given type of rotating machine. TLO 2.11 Suggest tools for maintenance of the given rotating machine.	**Unit - II Testing and Maintenance** 2.1 Objectives of testing. 2.2 Methods of testing : direct, indirect and regenerative. 2.3 Categories of Tests: routine, type, special and supplementary tests. 2.4 Tolerance. 2.5 Ingress protection, IP marking. 2.6 Significance of maintenance of electrical equipment. 2.7 Types of maintenance-routine, preventive, breakdown maintenance. 2.8 Factors affecting the preventive maintenance schedule. 2.9 Procedure for developing preventive maintenance schedule. 2.10 Foundations: requirements and factors affecting rotating machine foundation. 2.11 Tools/instruments: bearing puller, filler gauge, dial indicator, spirit level, megger, earth tester, growler, test lamps, multimeter, spanner sets, and screwdrivers.	Lecture Using Chalk-Board Presentations Video Demonstrations Model Demonstration Flipped Classroom Collaborative learning Case Study
3	TLO 3.1 Describe the procedural steps to be followed as per IS code of practice for maintenance of the given machine. TLO 3.2 Describe the procedural steps to be followed as per IS code of practice for testing of the given induction motor. TLO 3.3 Describe the procedural steps to be followed as per IS code of practice for testing of the given induction motor. TLO 3.4 Prepare the trouble shooting chart for the given type of induction motor.	**Unit - III Procedure for developing preventive maintenance schedule** 3.1 Recommended maintenance schedules: Single phase and three phase induction motors (IS 900 – 1992), three phase alternators and synchronous motors. 3.2 Induction motor testing: Routine, type and special test of single phase induction motor as per IS 7572 – 1974 and three phase induction motor as per IS4029 -2010. 3.3 Alternator and synchronous motor testing: Routine, type and special test of three phase alternator and synchronous motor as per IS 7132-1973. 3.4 Trouble shooting chart for single phase and three phase induction motor (IS 900 – 1992).	Lecture Using Chalk-Board Presentations Video Demonstrations Flipped Classroom Collaborative learning Case Study Site/Industry Visit

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
4	TLO 4.1 Describe the procedural steps to be followed as per IS code of practice for maintenance of the given transformer. TLO 4.2 Explain the specified test with its purpose and identify the terminals of a given type of transformer. TLO 4.3 Describe the procedural steps to be followed for finding voltage ratio of given transformer by various methods. TLO 4.4 Describe the Polarity test, Phasing out test, Back to Back test of given transformer. TLO 4.5 Prepare the trouble shooting chart for single phase and three phase transformers. TLO 4.6 Suggest the foundation requirement with sketch for the given type of transformer.	**Unit - IV Testing and trouble shooting of transformers** 4.1 Recommended maintenance schedules: transformers (IS 10028, part III – 1981) 4.2 Routine, type, supplementary, special tests of transformers, nomenclature of transformer terminals as per IS 2026-1981. 4.3 Measurement of voltage ratio by ratio meter, standard transformer, turn testing method. 4.4 Polarity test. 4.5 Phasing out test. 4.6 Back to Back test. 4.7 Trouble-shooting chart for single phase and three phase transformers. 4.8 Foundations: requirements for static machine foundations, factors governing them as per IS 10028 part 2.	Lecture Using Chalk-Board Presentations Video Demonstrations Flipped Classroom Collaborative learning Site/Industry Visit Case Study
5	TLO 5.1 Classify the insulation material for electrical equipment as per IS code of practice. TLO 5.2 State the factors affecting the life of insulating material. TLO 5.3 Describe the procedural steps to be adopted for measurement of insulation resistance by different methods. TLO 5.4 State the different properties and contaminating agents of transformer oil. TLO 5.5 Describe the procedural steps to be followed as per IS code of practice for testing of transformer oil. TLO 5.6 Describe the various methods of purification, cleaning of transformer oil and drying and re-varnishing of transformer windings. TLO 5.7 Prepare the sample history sheet for the specified electrical machine.	**Unit - V Testing and reconditioning of electrical machine insulation** 5.1 Classification of insulating materials as per IS 8504-1994. 5.2 Factors affecting life of insulating materials. 5.3 Measurement of insulation resistance by megger, voltmeter, dielectric absorption, polarisation index. 5.4 Transformer oil: properties, contaminating agents. 5.5 Testing of transformer oil as per IS 1866 : Dielectric strength test, acidity test, sludge test, crackle test, flashpoint and fire point test. 5.6 Reconditioning of insulation: centrifugal purifiers, streamline filter (Vacuum type) for purification and filtering of insulating oil. Cleaning and drying, re-varnishing, construction and working of vacuum Impregnation plant. 5.7 History sheets of transformers and induction motors: [Part A: machine specifications with component specifications (installation information, bearings, oil type, core weight etc. as applicable); Part B: date wise: observations of parameters such as voltage, current, temperature etc., symptoms, works carried out under maintenance).	Lecture Using Chalk-Board Presentations Video Demonstrations Flipped Classroom Collaborative learning Case Study

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Use fire extinguishers to extinguish the fire.	1	* Demonstration of Fire extinguisher available in the institute.	2	CO1
LLO 2.1 Apply artificial respiration in case of emergency.	2	* Demonstration of artificial respiration (Any convenient method).	2	CO1
LLO 3.1 Measure earth resistance.	3	* Measurement of earth resistance of electrical laboratory equipment.	2	CO1
LLO 4.1 Identify protective class of a given electric equipment.	4	*Protective class of a given electric equipment.	2	CO1
LLO 5.1 Get acquainted with the procedure for getting ISI mark.	5	* Visit BIS portal (bis.gov.in) for getting ISI mark/obtaining a license for electrical equipments and prepare a report for it.	4	CO1
LLO 6.1 Use tools/accessories applicable in the process. LLO 6.2 Identify the parts of a given motor.	6	* Dismantle and reassemble the given electrical machine and identify the various parts.	2	CO2
LLO 7.1 Use testing instrument for testing electrical equipment.	7	* Use of instruments for testing/maintenance of given electrical equipment.	2	CO2
LLO 8.1 Test given LED for ingress of water to confirm the IP rating.	8	* Testing of given 70 W or higher rating LED for ingress of water to confirm the IP rating	2	CO2
LLO 9.1 Carryout maintenance activities suggested in IS: 900-1992(Annex G) at 5,6,7 and 8 for maintenance of induction motors.	9	Maintainance of given induction motor.	2	CO3
LLO 10.1 Carryout maintenance activities suggested in IS: 10028- part 3 at 1,2,3 and 4for maintenance of transformer.	10	Maintainance of given transformer.	2	CO4
LLO 11.1 Identify the parts of single-phase induction motor. LLO 11.2 Rectify the basic faults in given single phase induction motor	11	Diagnosis and rectification of faults for a ceiling fan running slow.	1	CO3
LLO 12.1 Identify the parts of single-phase induction motor. LLO 12.2 Rectify the basic faults in given single phase induction motor.	12	Diagnosis and rectification of faults for a ceiling fan running in reverse direction.	2	CO3
LLO 13.1 Test the insulation condition of single-phase induction motor (before and after no load running)	13	Measurement of winding resistance of a single-phase induction motor by V-I method.	2	CO3
LLO 14.1 Test the three phase induction motor before commissioning.	14	* Reduced voltage running up test of three phase induction motor	2	CO3
LLO 15.1 Test the insulation condition of three phase induction motor (before and after no load running).	15	Measurement of phase winding resistance of a three-phase induction motor by V-I method.	2	CO3
LLO 16.1 Test the insulation condition of three phase induction motor (before and after conducting brake test).	16	Measurement of phase winding resistance of a three-phase induction motor by V-I method.	2	CO3
LLO 17.1 Identify primary and relevant secondary windings of transformer.	17	* Phasing out test of the three-phase transformer.	2	CO4

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 18.1 Identify the polarity of transformer windings.	18	* Polarity test of three phase transformer.	2	CO4
LLO 19.1 Apply regenerative method of testing.	19	Back-to-Back test on two identical single-phase transformers.	2	CO4
LLO 20.1 Test the dielectric strength of transformer oil. LLO 20.2 Using transformer testing oil kit.	20	Dielectric strength test of transformer oil.	2	CO5
LLO 21.1 Insulation resistance and dielectric strength of the windings in a single-phase induction motor applying high-voltage, ensuring that the motor can withstand operational voltage without failure	21	Test insulation resistance and dielectric strength of the windings of a single-phase induction motor.	2	CO5
LLO 22.1 Insulation resistance and dielectric strength of the windings in a three-phase induction motor by applying high-voltage, ensuring that the motor can withstand operational voltage without failure	22	Test insulation resistance and dielectric strength of the windings of a three-phase induction motor.	2	CO5
LLO 23.1 Measure insulation resistance of single-phase induction motor.	23	Measurement of insulation resistance of single-phase induction motor.	2	CO5
LLO 24.1 Measure insulation resistance of three phase induction motor.	24	Measurement of insulation resistance of three phase induction motor.	2	CO5
LLO 25.1 Measure insulation resistance of single phase transformer.	25	Measurement of insulation resistance of single-phase transformer.	2	CO5
LLO 26.1 Measure insulation resistance of three phase transformer.	26	Measurement of insulation resistance of three phase transformer.	2	CO5

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

SUGGESTED STUDENT ACTIVITIES

- Prepare report for step-by-step procedure to be followed for artificial respiration to be given to shock affected person.
- Prepare power point presentation on testing of Induction motor as per IS.
- Prepare power point presentation related to foundation of transformers.
- Collect sample of various class of insulating materials and prepare a chart of it.
- Prepare report for step-by-step procedure to be followed for VFD maintenance.

Assignment

- Elaborate various cooling methods of alternator.
- Prepare excel sheet for carrying out preventive maintenance schedule on any machine in lab.
- Elaborate Cable insulation HV test and cable conductor resistance measurement test using LCR meter.
- Collect information and prepare report on MSEDCL transformer maintenance.
- Elaborate various motor winding temperature measurement methods.
- Elaborate various transformer cooling methods.

Micro project

- Collect information on safety signs used for electrically hazardous areas and prepare charts for display in the laboratory or work place.
- Collect information on CPR Technique and prepare charts for display in the laboratory or work place.
- Visit electrical machine manufacturing unit and collect data of various tests conducted on it and submit a detailed report.
- Prepare a report on diagnosis of transformer oil sample by conducting various tests on it and submit a detailed report.
- Collect information of specifications, uses, cost of various tools and equipment needed for carry out maintenance of different electrical machines submit a detailed report.

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Fire extinguisher (powder type)	1
2	400V/230V, 50 Hz, 3-phase transformer with all phase winding terminals brought out for connections (suitable output in range of 2 kVA to 4 kVA).	10
3	Ceiling fan	11,12
4	AC-DC Ammeter range (0-2.5-5-10A) .	15,16,14
5	AC-DC Voltmeter Range (0-75/150/300V, 0 - 300V /600 V)	15,16,14
6	Single phase auto transformer 0-270 V, 15 A, input single phase, 230 V.	17,18,19
7	Three phase auto transformer 0-450 V, 15 A, input 3 phase, 400 V.	17,18,19
8	At least two identical 230 V/115 V or 400 V/ 230 V 50 Hz, 1 or 2 kVA single phase transformers.	18
9	Dielectric oil testing kit (with input at 230 V).	20
10	HV test kits for motors up-to 400 V.	21,22
11	Earth Resistance tester	3
12	230 V, 50 Hz, single phase capacitor start cage type induction motor (suitable available HP)	6,9
13	3-phase 5 HP, 400 V, 50 Hz, 1500 RPM squirrel cage induction motor with brake load arrangement as required.	6,9
14	Bearing puller, filler gauge, dial indicator, spirit level, megger, earth tester, growler, test lamps, multimeter, spanner sets, and screwdrivers.	7
15	LED lamp (70 W or higher rating)	8
16	3-phase 400V, 50 Hz, 1500 RPM slip ring induction motor about 5 HP.	9
17	Tachometers 0-5000 RPM minimum.	9,11,12,21,22
18	A.C. Watt meters: 0-300/600 V, 5/10 A or 10/20 A as needed.	9,11,12,21,22
19	LPF Wattmeter, 0-300/600 V, 1A to 2A.	9,11,12,21,22

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

MAINTENANCE OF ELECTRICAL EQUIPMENTS **Course Code : 316328**

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Safety and prevention of accidents	CO1	8	2	4	4	10
2	II	Testing and Maintenance	CO2	18	4	6	10	20
3	III	Procedure for developing preventive maintenance schedule	CO3	8	2	4	4	10
4	IV	Testing and trouble shooting of transformers	CO4	18	4	4	12	20
5	V	Testing and reconditioning of electrical machine insulation	CO5	8	2	2	6	10
Grand Total				**60**	**14**	**20**	**36**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- For formative assessment of laboratory learning 25 marks.
- Each practical will be assessed considering appropriate % weightage to process and product and other instructions of assessment.
- Two unit tests of 30 marks will be conducted and an average of two unit tests considered.

Summative Assessment (Assessment of Learning)

- End semester summative assessment of 25 marks for laboratory learning.
- End semester assessment of 70 marks through offline mode of examination.

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	3	3	2	3	3	-	3			
CO2	3	3	2	3	2	2	3			
CO3	3	3	2	3	2	2	3			
CO4	3	3	2	3	2	2	3			
CO5	3	3	2	3	2	2	3			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Bhattacharya S. K.	Electrical Machines	McGraw Hill Education. New Delhi, ISBN : 9789332902855
2	Theraja B.L.	Electrical Technology Vol-II (AC and DC machines)	S.Chand and Co.Ltd., New Delhi ISBN : 9788121924375
3	Bandyopadhyay M. N.	Electrical Machines Theory and Practice	PHI Learning Pvt. Ltd., New Delhi, ISBN :9788120329973 VI

Sr.No	Author	Title	Publisher with ISBN Number
4	Jean-Claude Trigeassous	Electrical Machine Diagnosis	John Wiley & Sons, IncISBN:978-1-84821-263-3.

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://www.youtube.com/watch?v=w4jHpHoYZhk	How to Use a Fire Extinguisher
2	https://www.youtube.com/watch?v=wrawEAaJrrY	Artificial respiration methods
3	https://www.youtube.com/watch?v=CvuDFgFFOa8	Fundamentals of Transformer Commissioning and Maintenance Testing
4	https://www.youtube.com/watch?v=ntOc4h792UE	Motor Maintenance & Troubleshooting
5	https://www.youtube.com/watch?v=uMxK6djp_rI	Electric Motor Repair & Rebuild Instructions
6	https://youtu.be/JvsPnGbUH5M	power transformer oil filtration and treatment
7	https://nptel.ac.in/	Relevant information from NPTEL
8	https://www.electricaltechnology.org/	Relevant information
9	https://www.electrical4u.com/	Relevant information

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students

Programme Name/s	**: Automation and Robotics/ Digital Electronics/ Electrical Engineering/ Electronics & Tele-communication Engg./ Electrical and Electronics Engineering/ Electrical Power System/ Electronics & Communication Engg./ Electronics Engineering/ Instrumentation & Control/ Industrial Electronics/ Instrumentation/ Medical Laboratory Technology/ Medical Electronics**
Programme Code	**: AO/ DE/ EE/ EJ/ EK/ EP/ ET/ EX/ IC/ IE/ IS/ ML/ MU**
Semester	**: Third / Fourth / Sixth**
Course Title	**: BASIC PYTHON PROGRAMMING**
Course Code	**: 313011**

I. RATIONALE

Electronics based industries needs to deal with creating circuits design, simulation, signal processing and control systems which can be developed using Python. This course deals with the basics of python to enhance the programming skills of diploma students. The course will enable students to write python programs as well as use different python libraries to solve given problems.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to attain the following industry/employer expected outcome through various teaching learning experiences:
Develop programs using python to solve wide-reaching electronics engineering related problems.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Develop script to demonstrate use of basic building blocks of python.
- CO2 - Implement conditional and looping statements for given problem statement.
- CO3 - Perform operations on sequence structures in python.
- CO4 - Implement basics of object oriented programming concepts.
- CO5 - Create modules and packages for given purpose.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme												
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
313011	BASIC PYTHON PROGRAMMING	BPP	AEC	2	-	2	-	4	2	-	-	-	-	-	25	10	25@	10	-	-	50

Total IKS Hrs for Sem. : 0 Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Describe the given Keywords and Constants in Python. TLO 1.2 Use indentation, comments in the given program. TLO 1.3 Use different types of operators for writing expressions. TLO 1.4 Write python program using input output statements.	**Unit - I Basic Python's Constructs** 1.1 Introduction to Python- Python as scripting Language, Programming language Vs Scripting Language (C vs Python), Python's Technical Strength, Application in different domains 1.2 Python's building blocks- Identifiers, Keywords, Variables, Constants, Indentation, Comments in python 1.3 Python's Data Types – Numbers, Strings, List, Tuples, Dictionaries, Sets 1.4 Input and Output statements in python 1.5 Operators in Python- Operators as Arithmetic, Assignment, Unary Minus, Relational, Logical, Boolean, Bitwise, Membership, Identity, Operator precedence and Associativity	Presentations, Lecture Using Chalk-Board, Hands-on
2	TLO 2.1 Develop programs using Conditional Statements. TLO 2.2 Develop programs using Loop statements. TLO 2.3 Use statements to control the loops.	**Unit - II Control Statements in Python** 2.1 Types of Control Statements – Decision making statements, Looping statements 2.2 Decision Making Statements: - if, if….else, else-if ladder ,nested if and switch statement 2.3 Looping statement: - while loop, for loop, nested loop 2.4 Manipulating Loops- use of break, continue and pass statements	Lecture Using Chalk-Board, Demonstration, Hands-on, Flipped Classroom

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
3	TLO 3.1 Develop program to manipulate List for given purpose. TLO 3.2 Develop program to manipulate Tuples for given purpose. TLO 3.3 Develop program to manipulate Sets for given purpose. TLO 3.4 Develop program to manipulate Dictionaries for given purpose.	**Unit - III Data Structures in Python** 3.1 List- Defining List, Creating list, Accessing values from list, Updating the elements of a list, Concatenation of two lists, Repeating of Lists, Membership in list, Aliasing and cloning Lists, Methods to process Lists, Nested Lists 3.2 Tuples- Defining Tuple, Creating Tuples, Accessing the Tuple elements, Inserting elements in a Tuple, modifying elements of a Tuple, Deleting elements from a Tuple, Basic operations in Tuples, Functions to process Tuples, Nested Tuples 3.3 Sets- Defining Set, Creating a Set, Accessing elements from set, Add and update Set, Remove an elements from a Set, Built in functions with Set, Set methods to perform mathematical operations, other relevant set methods 3.4 Dictionaries- Defining Dictionary, Creating Dictionary, Accessing elements from Dictionary, Add and update Dictionary, Delete an element from a Dictionary, Built in functions of Dictionary, Methods to perform Dictionary	Demonstration, Lecture Using Chalk-Board, Hands-on
4	TLO 4.1 Use python built-in functions to perform tasks. TLO 4.2 Develop relevant user defined function for the given purpose. TLO 4.3 Define classes to create and access objects with its methods and attributes.	**Unit - IV Functions with Basic OOP concepts** 4.1 Python Functions- Use of python built in functions (e.g. type/data conversion functions, math and string functions), User defined function- Function definition, function calling, function arguments and parameter passing, Return statement, scope of variables (Global and Local Variables) 4.2 Basic OOP concepts- Introduction to object-oriented programming, Creating classes and objects, Constructors and Destructors in python, Data abstraction and Encapsulation	Demonstration, Lecture Using Chalk-Board, Hands-on
5	TLO 5.1 Develop a python module in python for given purpose. TLO 5.2 Develop a python package for given purpose. TLO 5.3 Use NumPy for performing mathematical operations on arrays. TLO 5.4 Use matplotlib to create data visualization in python.	**Unit - V Modules and Packages in Python** 5.1 Modules- Writing modules, importing module, python built in modules (Numeric and mathematical module, Functional Programming Module) 5.2 Python packages- Introduction, Writing python packages, using standard packages (NumPy, matplotlib) and user defined package statements	Demonstration, Lecture Using Chalk-Board, Hands-on

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Install Python Integrated Development Environment.	1	a) Install and configure Python IDE. b) Write Python program to display message on screen.	2	CO1

BASIC PYTHON PROGRAMMING **Course Code : 313011**

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 2.1 Use operators in Python.	2	*a) Write simple Python program to calculate equivalent registers connected in series and parallel. Accept values of R1, R2 and R3 from the user. *b) Write simple Python program to calculate value of voltage by applying Ohm's law. Accept value of Current(I) and Resistance(R) from the user.	2	CO1
LLO 3.1 Implement two-way branching statement.	3	Write program to check whether entered frequency is radio frequency or audio frequency.	2	CO2
LLO 4.1 Implement multi-way branching statement.	4	*a)Write program to display various radio frequency bands using if..elseif ladder. *b)Write program to display resistor color code using switch statement.	2	CO2
LLO 5.1 Implement control loops for solving iterative problems.	5	*a. Write a simple Python program to demonstrate use of control loops: i) while ii) do while *b. Create a simple program, to demonstrate use of: for loop in Python (e.g.: various pattern building, printing multiplication table, checking palindrome number etc.)	2	CO2
LLO 6.1 Perform basic operations on the Lists.	6	*Write Python program to perform following operations on List: a) Create b) Access c) Update d) Delete elements from list.	2	CO3
LLO 7.1 Execute various tuple operations.	7	Develop Python program to perform following operations on Tuples: a) Create b) Access c) Update d) Delete Tuple elements	2	CO3
LLO 8.1 Implement various set operations.	8	Write Python program to perform following operations on Set: a) Create b) Access c) Update d) Delete Access Set elements	2	CO3
LLO 9.1 Execute various operations on Dictionaries.	9	*Create a program to perform following operations on Dictionaries in Python: a) Create b) Access c) Update d) Delete e) Looping through Dictionary	2	CO3
LLO 10.1 Use built-in mathematical functions and string functions in python.	10	a) *Create python program to demonstrate use of math built-in function. b) *Create python program to demonstrate use of string built-in function.	2	CO4

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 11.1 Create user defined functions in Python.	11	Write python programs to define function with arguments. a) Calculate factorial of a number b) Swapping of two variables	2	CO4
LLO 12.1 Implement function with default arguments.	12	Write programs to define function with default arguments.	2	CO4
LLO 13.1 Use built-in python mathematical modules.	13	*Create a program to demonstrate use of: Built-in module (e.g. numeric, mathematical functional and programming module) in Python.	2	CO5
LLO 14.1 Write user-defined module in python.	14	Write program to create a user-defined module (e.g.: building calculator) in python.	2	CO5
LLO 15.1 Use python built-in packages.	15	*Develop Python program to demonstrate use of NumPy package for creating, accessing and performing different array operations.	2	CO5
LLO 16.1 Implement user-defined packages in python.	16	Write program to demonstrate the use of user-defined packages in Python.	2	CO5

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

Micro project

- Not Applicable

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	a) Computer System with all necessary peripherals and internet connectivity. b)Any relevant python IDE like IDLE/PyCharm/VSCode/Jupiter Notebook/Online Python Compiler.	All

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

BASIC PYTHON PROGRAMMING **Course Code : 313011**

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Basic Python's Constructs	CO1	4	0	0	0	0
2	II	Control Statements in Python	CO2	4	0	0	0	0
3	III	Data Structures in Python	CO3	10	0	0	0	0
4	IV	Functions with Basic OOP concepts	CO4	6	0	0	0	0
5	V	Modules and Packages in Python	CO5	6	0	0	0	0
Grand Total				**30**	**0**	**0**	**0**	**0**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Each practical will be assessed considering – 60% weightage to process and – 40% weightage to product.

Summative Assessment (Assessment of Learning)

- End semester summative assessment of 25 marks for laboratory learning.

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	2						1			
CO2	2			1			2			
CO3	1	1	1	2			2			
CO4	1	2	2	2			2			
CO5	1	1	1	2			2			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Giancarlo Zaccone	Natural Computing with Python	BPB, ISBN:9789388511612
2	Martin C. Brown	Python: The Complete Reference	Tata McGraw Hill ISBN: 9789387572942
3	Yashwant Kanetkar	Let Us Python	BPB, ISBN: 978-9391392253
4	Kumar Naveen, Taneja Sheetal.	Python Programming: A modular approach	Pearson, ISBN: 978-9352861293
5	Mark Lutz and David Ascher	Learning Python	O'Reilly, ISBN: 978-1449355739
6	Paul Barry	Head First Python	O'Reilly, ISBN: 978-1449382674
7	John Guttag	Introduction to Computation and Programming Using Python	MIT Press, ISBN: 978-0262529624

Sr.No	Author	Title	Publisher with ISBN Number
8	David Beazley	Python Essential Reference	Addison-Wesley Professional, ISBN: 978-0672329784
9	Dr. R. Nageswara Rao	Core Python Programming	DREAMTECH PRESS, ISBN: 978-9386052308

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://www.programiz.com/python-programming	Python Programming
2	https://python-iitk.vlabs.ac.in/Introduction.html	Virtual Lab for Python Programming-Basic Constructs in Python
3	https://www.geeksforgeeks.org/python-programming-language/	Python Programming
4	https://intellipaat.com/academy/course/introduction-to-python-programming-free-course/	Online Course-Python Programming
5	https://www.w3schools.com/python/	Python Programming
6	https://www.tutorialspoint.com/python/index.htm	Python Programming
7	https://www.python.org/	Python Programming
8	https://spoken-tutorial.org/tutorial-search/?search_foss=Python+3.4.3&search_language=English	Spoken Tutorial on Python Programming

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students

Programme Name/s	**: Automobile Engineering./ Artificial Intelligence/ Artificial Intelligence and Machine Learning/ Automation and Robotics/ Cloud Computing and Big Data/ Civil Engineering/ Chemical Engineering/ Computer Technology/ Computer Engineering/ Civil & Rural Engineering/ Construction Technology/ Computer Science & Engineering/ Digital Electronics/ Data Sciences/ Electrical Engineering/ Electronics & Tele-communication Engg./ Electrical and Electronics Engineering/ Electrical Power System/ Electronics & Communication Engg./ Electronics Engineering/ Computer Hardware & Maintenance/ Industrial Electronics/ Information Technology/ Computer Science & Information Technology/ Civil & Environmental Engineering/ Mechanical Engineering/ Mechatronics/ Production Engineering/ Computer Science/ Electronics & Computer Engg.**
Programme Code	**: AE/ AI/ AN/ AO/ BD/ CE/ CH/ CM/ CO/ CR/ CS/ CW/ DE/ DS/ EE/ EJ/ EK/ EP/ ET/ EX/ HA/ IE/ IF/ IH/ LE/ ME/ MK/ PG/ SE/ TE**
Semester	**: Sixth**
Course Title	**: CAPSTONE PROJECT**
Course Code	**: 316004**

I. RATIONALE

Capstone projects in engineering study are considered important as it allow students to integrate and apply the knowledge and skills acquired throughout their academic program and effectively demonstrating their learning of programme by tackling a real-world problem, ultimately keeping them well prepared for the job market. The capstone project is usually the final assignment and plays a vital role in preparing students for the world of work to its practical applications and ability to help hone students' professional knowledge and skills. Normally, capstone projects are developed in collaboration with industries or businesses, providing students with valuable insights. Capstone projects has been considered as an integral part of diploma curriculum. It helps learners to perform and demonstrate skills gained due to early courses of Diploma study independent. Therefore, this is considered as a course of final year/semester study.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- Apply professional skills for solving , executing and demonstrating solutions to real-world problems

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Elaborate the identified field problem from the perspective of project work at institute.
- CO2 - Conduct feasibility & viability analysis (using data collection, experiments, Simulation , Coding) to validate required resources, cost, support of the project work.
- CO3 - Apply the acquired knowledge and skills in providing solutions to the real field/industrial problems.
- CO4 - Present Project and its output/ findings / achievements alongwith its exhibits.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme												
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
316004	CAPSTONE PROJECT	CPE	INP	-	-	2	2	4	2	-	-	-	-	-	50	20	50#	20	50	20	150

V. General guidelines for PROJECT WORK

- The Project- problems must be related to the programme or may be interdisciplinary, based on the industry expected outcomes.
- The individual students have different aptitudes and strengths. Project work, therefore, should match the strengths of students. For this purpose, students should be asked to identify the type of project work they would like to execute.
- Project titles are to be finalized in co-ordination/consultation with the Faculty mentor. However, faculty may form a team of students as per specific roles- Literature survey/data collection, data Analysts, model/prototype developers, testers, Project managers using IoTs ITES and software /application development. Study type project is NOT advisable.
- Project must be assigned to a group of 3-4 students under the guidance of identified faculty mentor.
- Students are required to prepare a prototype/working model/software of the Project and simultaneously prepare a report.
- Students shall Submit One Hard copy and one Soft copy each of Project Report and soft-copy of the project code or the working model.
- Students must maintain a project execution diary having the progress steps and details. The concerned faculty should check the diary on a weekly basis and accordingly interact with students based on the progress shown and keep proper record with feedback if any.
- Project shall address National Thrust area such as Environment, Digitization, Automation, sustainability and similar domains.
- Student shall try to use the national and international standards wherever possible (processes / materials / equipments etc ..)

VI. Project facilitation guidelines:

Once the Project statement has been finalized and allotted to the students, the Faculty Mentor role is very important as guide, motivator, catalyser to promote learning and sustain the interest of the students. At the same time the Faculty Mentor is not expected to guide the students on each step, otherwise it will curb the creativity of the students-group. The Faculty Mentor has to work as a mentor. Following should be kept in mind while facilitating the project at the institute:

1.Project orientation cum -briefing: the project should be relevant to the curriculum of the programme. The project shall be cost effective taking safety aspects, ethical issues, environmental issues and confidentiality as per expectation of industry(if any) into consideration, The work may be industry Sponsored.

2.Information search and data collection: the information and data should be realistic and relevant to the problem /project. Hypothetical data is not to be taken into consideration.

3.Implementation and Monitoring: The project must have important steps /milestones to achieve as per the time frame/action plan prepared by students and faculty. The monitoring mechanism such as daily/weekly dairy (**Format given below)** must be clearly explained and delineated for the students.

VII.Criteria of Assessment /Evaluation of Project work

A. Formative Assessment (FA) criteria

The **Formative Assessment** (FA) of the students for 50 marks is to be done based on following criteria.

Appropriate RUBRICS may be used for assessment

Rubrics for Assessment of the team

Sr.No.	Criteria	Marks
1	Project Selection & Problem definition	05
2	Literature survey and data collection/ Gathering	05
3	Design / concept of project/ Working - Execution of Project	10
4	Stage wise progress as per Action plan/milestone	05
5	Quality Report Writing	05

Rubrics for Individual Assessment

Sr.No.	Criteria	Marks
1	Contribution as a team member	05
2	Depth of Knowledge	10
3	Presentation	05

B. Summative Assessment Criteria

- The summative assessment for 50 marks is to be done and based on following criteria. This assessment shall be done by the faculty mentor and External examiner.

Sr.No.	Criteria	Marks
1	Capstone Project Completion as per plan	10
2	Project related Requirement Analysis & Designing	10
3	Developing a Solution with proper justifications, Teamwork	10
4	Project Report Writing	10
5	Project Presentation	10

(**NOTE :** Team based and Individual performance based summative assessment may include Innovativeness , Technology used , user friendliness , cost effectiveness , society benefits etc..)

SUGGESTED RUBRIC FOR SUMMATIVE ASSESSMENT OF CAPSTONE PROJECT

PROJECT ASSESSMENT				
Project Title:				
Project Assessment Rubric				
Performance	**Excellent**	**Good**	**Fair**	**Poor**
Criteria	**9-10 marks.**	**6-8 marks.**	**4-5 marks.**	**0-3 marks**
Capstone Project Completion	Excellent **The project is completed as per tasks described in synopsis.**	Good **The project is completed but require minor modifications.**	Fair **The project is completed but require several modifications.**	Poor **The project is not completed as per tasks described in synopsis.**

Project related Requirement Analysis & Designing	**9-10 marks.**	**6-8 marks.**	**4-5 marks.**	**0-3 marks**
	Effectively contributed in requirement analysis and designing.	**Partially Contributed in requirement analysis and designing.**	**Attempted to contribute in requirement analysis and designing**	**No contribution in requirement analysis and designing.**
Developing a Solution with proper justifications , Teamwork	**9-10 marks.**	**6-8 marks.**	**4-5 marks.**	**0-3 marks**
	Developed the critical solution modules with Innovation, optimized design and worked very well with the team.	**Developed some solutions with higher complexity and worked well with the team.**	**Attempted to develop few solutions and worked with the team.**	**No contribution in developing a solution and in the team.**
Project Report Writing	**9-10 marks.**	**6-8 marks.**	**4-5 marks.**	**0-3 marks**
	Worked very well to submit an excellent project report .	**Worked well to submit the project report with covering all the aspects of a standard report.**	**Tried to submit the project report but standard of report was not satisfactory.**	**No contribution in project report writing.**
Project Presentation	**9-10 marks.**	**6-8 marks.**	**4-5 marks.**	**0-3 marks**
	Presented the project work flawlessly.	**Presented the project work very nice.**	**Presented the project work not so well.**	**Presentation skill is not up to the mark.**
Project Group Members				
ROLL NUMBER/Enrollment Number				
NAME				
Comments (if any)				

NOTE : " These are suggestive rubrics Faculty mentor and external examiner may frame different rubrics as per Programme need and assigned Project work "

C. Self Learning Assessment

Self Learning Assessment **Max Marks -50**

Sr.No.	Criteria	Max Marks	Marks Obtained
1	Project Selection & Problem definition	10	
2	Literature survey and data collection/ Gathering	05	
3	Design / concept of project/ Working - Execution of Project	15	
4	Stage wise progress as per Action plan/milestone/ psychomotor motor skills acquired	10	
5	Quality Report Writing	10	

VIII. CO-PO Mapping

CO-PO mapping will vary project wise and shall be prepared by concerned faculty for the given project

IX. Typographical instructions/guidelines for Project report writing

Following is the suggestive format for preparing the Project report. Actual report may differ slightly depending upon the nature of industry. The training report may contain the following.

a. The PROJECT report shall be computer typed (English- British) and printed on A4 size paper.
b. Text Font -Times New Roman (TNR), Size-12 point
c. Subsection heading TNR- 12 point bold normal
d. Section heading TNR- 12 capital bold
e. Chapter Name/ Topic Name – TNR- 14 Capital
f. All text should be justified. (Settings in the Paragraph)
g. The report must be typed on one side only with double space with a margin 3.5 cm on the left, 2.5 cm on the top, and 1.25 cm on the right and at bottom.
h. The training report must be hardbound/ Spiralbound with cover page in black colour. The name of the candidate, diploma (department), year of submission, name of the institute shall be printed on the cover [Refer sample sheet (outer cover)]
i. The training report, the title page [Refer sample sheet (inner cover)] should be given first then the Certificate followed by the acknowledgment and then contents with page numbers.

X. Project Report

On completion of the project work, every student will submit a project report which should contain the following:
1. Cover Page (as per annexure 1)
2. Title page (as per annexure 2)
3. Certificate by the Guide (as per annexure 3)
4. Acknowledgment (The candidate may thank all those who helped in the execution of the project.)
5. Abstract (It should be in one page and include the purpose of the study; the methodology used.)
6. Table of Contents (as per general guidelines): Detailed description of the project (This should be split in various chapters/sections with each chapter/section describing a project activity in totality).

Chapter–1 Introduction (background of the Industry or User based Problem/Task)
Chapter–2 Literature Survey (to finalize and define the Problem Statement)
Chapter–3 Scope of the project
Chapter–4 Methodology/Approach, if any
Chapter-5 Details of designs, working and processes
Chapter-6 Results and Applications

7. Conclusion
8. References (The listing of references should be typed 2 spaces below the heading “REFERENCES” in alphabetical order in single spacing left – justified. It should be numbered consecutively (in square [ ] brackets, throughout the text and should be collected together in the reference list at the end of the report. The references should be numbered in the order they are used in the text. The name of the author/authors should be immediately followed by the year and other details). Typical examples of the references are given below:

NOTE:
1. Project report must contain only a relevant and short mention – technology or platform or tools used. It must be more focussed on project work and its implementation
2. Students can add/remove/edit chapter names as per the discussion with their guide

Formats

Project Report

"Project Title----------"

as a partial fulfilment of requirement of the

THIRD YEAR DIPLOMA IN

Submitted by

1)Name Of Student	**Enrollment Number**
2)Name Of Student	**Enrollment Number**
3)Name Of Student	**Enrollment Number**
4)Name Of Student	**Enrollment Number**

Are the bonafide on

FOR THE ACADEMIC YEAR

20-----20---

(H.O.D)

(Principal)

(Internal Guide) **(External Examiner)**

Department Name

(If NBA Accredited mention that)
Institute Name

(An Affiliated Institute of Maharashtra State Board of Technical Education)

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Note:

***Students can add/remove/edit chapter names as per the discussion with their guide**

Annexure

PROJECT DIARY (Weekly/Daily)

Name of the Student : _____

Name of Guide (Faculty) : _____

Enrollment Number : _____ Semester: _____Project batch Number : _____

WEEK : _____

Date	Activity carried out (Details)	Achievement of mile stone/step as per plan	Remark of Faculty
Monday			
Tuesday			
Wednesday			
Thursday			
Friday			
Saturday			

Dated Signature of Faculty **Dated Signature of HOD**

MSBTE LOGO INST LOGO

Certificate

This is to certify that

Mr./Ms. *bearing examination seat No.* *has*

Satisfactorily completed his/her ***PROJECT*** *entitled*

Along with his/her batchmates in partial fulfillm ent for the

Diploma Course in

< PROGRAMME NAME>

Of the ***Maharashtra State Board of Technical Education*** *at our Polytechnic during the Academic Year20 -20 .*

The Project is completed by a group consisting of Persons under the guidance of the Faculty Guide

Faculty Name and Signature (Internal)	**Faculty Name and Signature (External if applicable)**	**HOD Name and Signature with Department Stamp**
Date and Time		

INDUSTRIAL AUTOMATION **Course Code : 316329**

Programme Name/s : **Electrical Engineering/ Electrical Power System**

Programme Code : **EE/ EP**

Semester : **Sixth**

Course Title : **INDUSTRIAL AUTOMATION**

Course Code : **316329**

I. RATIONALE

Every industry is moving towards automation. Industries rely heavily on automation for economic feasibility, mass production and more quality. This course will enable the diploma students to apply the basics of automation and control the process/production using Program Logic Controller(PLC), Supervisory Control and Data acquisition (SCADA) and Distributed Control System (DCS) in automation. This course will provide an opportunity to learn industrial automation techniques.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help the student to attain the following industry-identified competency through various teaching-learning experiences ;

- **Automate production lines using PLC, SCADA and DCS**

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Develop control and power circuits for the given application
- CO2 - Apply the fundamentals of PLC for effective operation
- CO3 - Apply the basics of PLC programming for a given application
- CO4 - Test ladder logic programs for given industrial applications
- CO5 - Familiarize the SCADA and DCS architecture for process contol and data acquisition from the field.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
316329	INDUSTRIAL AUTOMATION	EIA	DSE	3	-	2	1	6	3	3	30	70	100	40	25	10	25#	10	25	10	175

Total IKS Hrs for Sem. : 0 Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Interpret the device and its function based on its symbolical representation TLO 1.2 Describe the working of a given Input/output device used in Industrial Control Circuits TLO 1.3 Differentiate the operation of the control and power circuit for the given motor control circuit TLO 1.4 Develop control and power circuits for the given process control application(s).	**Unit - I Industrial Control Circuits** 1.1 Need and benefit of automation, Different input devices such as push button, selector switch, limit switch, proximity switch and pressure switch. 1.2 Different output devices such as relay, contactor, solenoid valve, solid state relay (SSR) 1.3 Different symbols used in industrial control circuits. Concept of control and power circuit diagram. 1.4 Commonly used motor control circuits - a) DOL starting b) Star-delta starter c) FWD-STOP-REV control and random reversing of induction motor. d) Soft Starters 1.5 Typical control and power circuit diagrams of hoist control, conveyer control (Interlocking of minimum three conveyors)	Lecture Using Chalk-Board Presentations Case Study Flipped Classroom Model Demonstration Video Demonstrations Demonstration Hands-on Site/Industry Visit

INDUSTRIAL AUTOMATION **Course Code : 316329**

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
2	TLO 2.1 Describe architecture of PLC with a neat block diagram along with functions of each part TLO 2.2 Describe CPU functioning and memory organization of PLC TLO 2.3 Describe Redundancy concept in PLC TLO 2.4 State specifications of given PLC TLO 2.5 Enlist different brand and model of PLC's available in the market TLO 2.6 Explain the need and significance of International standard for PLC IEC 61131-1, IEC 61131-2, IEC 61131-3	**Unit - II PLC Fundamentals** 2.1 Architecture of PLC : Block Diagram and function of each block 2.2 CPU Working : PLC Scan Cycle, Speed of execution, working modes of CPU (Programming, RUN,REM Modes) 2.3 Redundancy and memory organization of PLC 2.4 Classification of PLCs: According to structure, Size. Advantages of PLC based automation over relay based automation, Specifications of PLC, Different PLCs available in market, PLC comparison with PC 2.5 Digital and Analog IO modules of PLC, Block diagram and specification, Function of communication module 2.6 Micro PLC : Introduction, comparison with PLC, Applications 2.7 International standard for PLC IEC 61131-1, IEC 61131-2, IEC 61131-3	Lecture Using Chalk-Board Presentations Case Study Flipped Classroom Model Demonstration Video Demonstrations Demonstration Hands-on Site/Industry Visit
3	TLO 3.1 State features of PLC programming languages TLO 3.2 Develop Ladder diagram for different logic gates TLO 3.3 Develop the PLC ladder programs for the given situations. TLO 3.4 Describe program scan process for the given type of PLC TLO 3.5 Describe various types of PLC instructions	**Unit - III Basics of PLC Programming** 3.1 Binary system, bit, byte, word, logic gates, PLC Programming languages : Ladder Logic ,Sequential Function Charts (SFC), Function Block Diagram (FBD), Structured Text (ST), Instruction List(IL) - (Only Introduction , Advantages and Disadvantages) 3.2 Programming PLC using ladder diagram, Components of ladder diagram, Program scan process applied to single rung. 3.3 Ladder diagram for different logic gates : AND, OR, NOR and XOR 3.4 PLC Instructions : (i) Bit type instructions- XIC, XIO, OTE, OTL, OUT, OSR (ii) Logical instructions- OR, AND, NOT, XOR (iii) Comparison instructions- EQU, NEQ, LES, LEQ, GRT, GERQ, LIM (iv) Timer instructions- TON, TOFF, RTO (v) Counter instructions- CTU, CTD (vi) Scaling instructions- SCP	Lecture Using Chalk-Board Presentations Case Study Flipped Classroom Model Demonstration Video Demonstrations Demonstration Hands-on Site/Industry Visit
4	TLO 4.1 Explain the function of seal in circuit in ladder logic TLO 4.2 Explain the use of Latch relay in PLC programming TLO 4.3 Develop PLC ladder logic for given Industrial application	**Unit - IV Advanced PLC Programming** 4.1 Seal in circuit 4.2 Latching Relay using PLC 4.3 System Design, I/O listing, Wiring Diagram and Ladder Logic for Industrial Applications : DOL starter with OLR, water level controller, Forward reverse control of 3-phase IM, Temperature control (ON/OFF), Stepper motor control , Bottle filling system, Traffic Light Control	Lecture Using Chalk-Board Presentations Case Study Flipped Classroom Model Demonstration Video Demonstrations Demonstration Hands-on Site/Industry Visit

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
5	TLO 5.1 Explain SCADA system architecture used in Industrial Automation with the help of Block diagram TLO 5.2 Explain DCS system architecture used in Industrial Automation with the help of Block diagram TLO 5.3 Compare PLC, SCADA and DCS	**Unit - V SCADA and DCS** 5.1 Supervisory Control and Data acquisition (SCADA): Basic function, generalized block diagram, function of each block, interfacing SCADA with PLC, simple mimic diagrams, applications of SCADA 5.2 Distributed Control System: Basic function, generalized block diagram, function of each block, applications of DCS 5.3 Comparison of PLC, SCADA and DCS	Lecture Using Chalk-Board Presentations Case Study Flipped Classroom Model Demonstration Video Demonstrations Demonstration Hands-on Site/Industry Visit

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Interpret different symbols used in a given industrial control diagram	1	* Identification of symbols used in industrial control diagrams.	2	CO1
LLO 2.1 Simulate a simple seal-in circuit using PLC simulator. LLO 2.2 Addressing of Input and output devices	2	Simulation of a simple seal-in circuit using PLC simulator.	2	CO4
LLO 3.1 Connect PLC to PC LLO 3.2 Addressing properly different input and output devices LLO 3.3 Test the ladder logic programs for basic logic gates operations (AND, OR, XOR, NOR)	3	Testing of the ladder logic program for basic logic gates operations	2	CO2
LLO 4.1 Draw logic diagram to create 10 second delay after a push button press using timer instruction block LLO 4.2 Address properly the input, output devices and timer instruction/block LLO 4.3 Test the ladder logic	4	PLC program to create a delay using a given timer function	2	CO3
LLO 5.1 Draw ladder logic diagram for connecting a star delta starter to a 3 phase induction motor LLO 5.2 Address properly the input output devices LLO 5.3 Test the ladder logic program	5	Ladder logic program for STAR-DELTA staring of a 3ph. Induction motor	2	CO3
LLO 6.1 Draw ladder logic diagram for controlling the direction of rotation for a 3 phase induction motor LLO 6.2 Address properly the input output devices LLO 6.3 Test the ladder logic program LLO 6.4 Interface the 3 phase induction motor to the PLC with the help of Motor module	6	* Reversal of Direction of rotation of 3ph. Induction motor with the help of PLC.	2	CO4

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 7.1 Draw ladder logic diagram for controlling the direction of rotation for a steeper motor LLO 7.2 Address properly the input output devices LLO 7.3 Test the ladder logic program LLO 7.4 Interface the steeper motor to the PLC with the help of Motor module	7	Control of the direction of rotation of a given stepper motor.	2	CO4
LLO 8.1 Draw ladder logic diagram for controlling the temperature of given process LLO 8.2 Address properly the input devices (Temperature Sensor) LLO 8.3 Test the ladder logic program LLO 8.4 Interface the Temperature sensor to the PLC	8	* Control of Temperature with the help of PLC	2	CO4
LLO 9.1 Draw ladder logic diagram for controlling the traffic lights. LLO 9.2 Address properly the input and ouput devices LLO 9.3 Test the ladder logic program	9	* Simulating traffic light control with the help of PLC	2	CO4
LLO 10.1 Draw ladder logic diagram for blinking of light. LLO 10.2 Address properly the input and output devices LLO 10.3 Test the ladder logic program	10	Ladder logic for blinking of a lamp	2	CO3
LLO 11.1 Draw ladder logic diagram to simulate given gate LLO 11.2 Address properly the input and output devices LLO 11.3 Test the ladder logic program	11	*Implementation of Logic gates using PLC using Virtual Lab	2	CO3
LLO 12.1 Draw ladder logic diagram for bottle filling plant. LLO 12.2 Address properly the input and output devices LLO 12.3 Test the ladder logic program LLO 12.4 Interface the input and output devices to the PLC	12	* Ladder logic for automatic bottle filling plant using virtual lab	2	CO4
LLO 13.1 Draw ladder logic diagram for automatic water tank level control LLO 13.2 Address properly the input and output devices LLO 13.3 Test the ladder logic program LLO 13.4 Interface the input and output devices to the PLC	13	* Automatic water tank level control system using PLC	2	CO4
LLO 14.1 Identify various features and properties of SCADA system	14	Identification of various components in library/ Wizard and properties of SCADA software	2	CO5
LLO 15.1 Identify hardware and software platform for DCS using virtual lab	15	* Identification of hardware and software platform for DCS using virtual lab	2	CO5

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

Micro project

- Display temperature and humidity at the entrance of the institute and institute campus. Compare the reading and submit a report
- Prepare a project of Automatic bottle filling plant on conveyor belt using SCADA software
- Prepare a project indicating historical/real-time trend for an event using SCADA software
- Design a small automation model for automatic ON/OFF control of a light in a room according to occupancy in the room
- Automatic railway gate controlling system
- Demonstration of five axes rotation of Robotic Arm
- Control of servo-motor and stepper motor by using Raspberry Pi 4.0
- Report on PLC-based Speed Control of Electric Vehicle
- Operate Robot-Based Welding Automation

Market Survey

- Make a survey of commercially available PLCs in the market.
- Make a survey of industrial control components based on their ratings.

Industry Visit

- Visit any manufacturing / process plant having PLC automation
- Visit any manufacturing / process plant having SCADA and / or DCS
- Visit any manufacturing/process plant having a Robotic automation

Assignment

- Give the selection criteria of I/O modules in automation system
- Enlist International manufacturers of PLC/SCADA/DCS/HMI
- Write the report on the use of DCS in oil and gas refineries
- Write the report on DCS used in water treatment plants

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Push buttons, indicating lamps , float switch, Selector Switch ,Limit switch, proximity switch (Capacitive, Inductive , Magnetic), Pressure switch (Danfoss KP36 or equivalent) - Each 4 Nos.	1
2	Sensors : Proximity - Inductive, LVDT, Capacitive, Ultrasonic, Optical, Temperature, Flow, pressure, piezoelectric, photoelectric - Each 4 Nos.	1
3	DIN rail mounted AC contactor, 3 power poles with 1 NO and 1 NC contact	1
4	COEP Technological University's Virtual Lab (Industrial Automation and Programmable Logic Controller Laboratories under Electrical Department.)	11,12,15
5	Float switch , solenoid valve	13
6	Any SCADA software	14
7	PLC with min 8 I/Os and HMI and its simulation/programming software.(1 No.)	2,3,4,5,6,7,8,9,10,13
8	Induction motor drive model	6
9	Stepper motor drive module.	7

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Industrial Control Circuits	CO1	7	0	2	4	6
2	II	PLC Fundamentals	CO2	10	2	8	8	18
3	III	Basics of PLC Programming	CO3	10	2	8	8	18
4	IV	Advanced PLC Programming	CO4	10	2	8	8	18
5	V	SCADA and DCS	CO5	8	2	0	8	10
Grand Total				**45**	**8**	**26**	**36**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Two unit tests of 30 marks will be conducted and average of marks obtained in these two unit tests will be considered. Each practical will be assessed for 25 marks and average of all marks obtained will be considered.

Summative Assessment (Assessment of Learning)

- End semester assessment of 70 marks for classroom learning. End semester assessment of 25 marks for laboratory learning.

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	3	3	3	2	2	2	3			
CO2	2	2	2	2	2	-	2			
CO3	3	2	2	2	2	-	2			

CO4	3	3	3	3	2	3	3			
CO5	2	2	3	3	2	2	2			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Bhattacharya, S.K.; Singh, B.	Control of Machines	New Age International Publishers, New Delhi, 2006, ISBN: 978122418187
2	Eswar, U.S.	Handbook of Electrical Motor Control Systems	McGraw Hill Education, New Delhi, 2013, ISBN : 978-0074601112
3	Madhuchhanda Mitra , Samarjt Sengupta	Programmable Logic Controllers and Industrial Automation: An Introduction	Penram International Publication , New Delhi,2017, ISBN : 978-8187972631
4	Stuart A. Boyer	SCADA: Supervisory Control and Data Acquisition	ISA, 1999, ISBN : 1556176600, 9781556176609
5	Garry Dunning	Introduction to Programmable logic Controller	Delmar Cengage learning ISBN-13978-1401884260 Edition 3 Publication Date-16 December 2005
6	Boyar S.A	Supervisory control and data acquisition	ISA Publication, USA ISBN: 978-193600709
7	Bhatkar Vijay P.	Distributed computer control system in industrial automation	Routledge 2017 : ISBN 9781351454698
8	Frank D. Petruzella	Programmable Logic Controllers	McGraw Hill ISBN - 13978-9353167271

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://portal.coepvlab.ac.in/vlab/auth/home?dept=3&lab=4	Virtual Lab for PLC : from COEP Technological University , Pune
2	https://portal.coepvlab.ac.in/vlab/auth/home?dept=3&lab=2	Virtual Lab for Industrial Automation : from COEP Technological University , Pune
3	https://www.youtube.com/watch?v=PLYosK87D8E	PLC basics
4	https://www.youtube.com/watch?v=Hci-eW5IihM	Basics of PLC Ladder Diagram
5	https://www.youtube.com/watch?v=1pRv-p_HbRk	Controlling Water Level in the PLC Ladder Logic Program
6	https://www.youtube.com/watch?v=3WATUnwCwRA	Mastering PLC Programming: Traffic Light Control
7	https://www.youtube.com/watch?v=8UQOhGp8gqY	Basic PLC bottle filling process
8	https://youtu.be/86uY3TQq2Yk?si=tpM6Rh4CFOmQONJY	Introduction to SCADA Systems | What is SCADA?
9	https://youtu.be/DlFOIoFjJwc?si=Zlq8BIzSzxW36kOY	DCS vs PLC | Understanding the Differences and Applications

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students

INDUSTRIAL DRIVES AND CONTROL **Course Code : 316330**

Programme Name/s : **Electrical Engineering/ Electrical Power System**
Programme Code : **EE/ EP**
Semester : **Sixth**
Course Title : **INDUSTRIAL DRIVES AND CONTROL**
Course Code : **316330**

I. RATIONALE

Industries are moving towards automation. The conventional speed control methods of motors are replaced by solid state drives which result in accurate, fast, precise speed, torque and power control to match the requirement of different type of loads. This course will enable the diploma students to develop cognitive, psychomotor and affective domain skill sets to control the speed and torque of a given motor and maintain the control circuits used in the field.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help the student to attain the following industry-identified competency through various teaching-learning experiences ;

- **Control precisely the speed, torque and power of different motors to ensure optimal performance of industrial drive system.**

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Apply the basics of electric drive for precise motor control operation.
- CO2 - Use appropriate braking method for different AC and DC motors.
- CO3 - Control precisely the speed of a given DC motor using appropriate phase-controlled converter and chopper.
- CO4 - Control precisely the speed of a given Induction Motor using appropriate AC Drive technique.
- CO5 - Control precisely the speed of a given motor using advanced techniques.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
316330	INDUSTRIAL DRIVES AND CONTROL	IDC	DSE	3	-	2	1	6	3	3	30	70	100	40	25	10	25#	10	25	10	175

Total IKS Hrs for Sem. : 0 Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Describe the fundamental building blocks along with its function of typical electric drive. TLO 1.2 Classify Electric drives. TLO 1.3 Write the fundamental torque equation of motor load system specifying each parameter. TLO 1.4 Describe briefly four quadrant operation in an electric drive with neat labeled sketches. TLO 1.5 Classify the different components of load torque. TLO 1.6 Identify stable and unstable region of operation in speed-torque characteristics of a three-phase induction motor.	**Unit - I Basics of Electric Drives** 1.1 Electric Drive – Definition, block diagram and basic building blocks of an electric drive system. 1.2 Classification of Drives – AC, DC, Permanent Magnet Synchronous Motor (PMSM), Special motor drives. 1.3 Fundamental torque Equation 1.4 Multi-quadrant operation 1.5 Components of Load torque 1.6 Nature and classification of Load torque 1.7 Steady State Stability (No derivation)	Demonstration Lecture Using Chalk-Board Model Demonstration Video Demonstrations Flipped Classroom Presentations
2	TLO 2.1 Define braking. TLO 2.2 State different types of braking along with its advantages. TLO 2.3 Describe different braking methods used for DC series motor and DC shunt motor along with diagrams. TLO 2.4 Describe different braking methods used for three phase induction motors. TLO 2.5 Describe eddy current braking along with its applications.	**Unit - II Braking of Electric Motors** 2.1 Braking – Definition, types and advantages. 2.2 Braking of DC Series and DC Shunt Motor - Dynamic braking/Rheostatic braking , Regenerative braking and Plugging. 2.3 Braking of induction motor (Three Phase)- Rheostatic braking, Regenerative braking and Plugging. 2.4 Eddy current braking- Principle and application	Video Demonstrations Demonstration Flipped Classroom Lecture Using Chalk-Board Site/Industry Visit Presentations Model Demonstration

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
3	TLO 3.1 Describe a given type of single phase controlled converter fed separately excited DC motor drive with diagrams. TLO 3.2 Describe a given type of three phase controlled converter fed separately excited DC motor drive with diagrams. TLO 3.3 Describe basic chopper circuit. TLO 3.4 Classify choppers based on output voltage and quadrant operations. TLO 3.5 Describe the working of a given type of chopper based on quadrant operations. TLO 3.6 Describe the function of chopper controlled drives in solar and battery powered electric vehicles along with block diagrams.	**Unit - III DC Drives** 3.1 Single phase controlled converter fed separately excited DC motor drive 3.1.1 Single phase half wave converter drive. 3.1.2 Single phase semi converter drive. 3.1.3 Single phase full converter drive. 3.1.4 Single phase dual converter drive. 3.2 Three phase controlled converter fed separately excited DC motor drive 3.2.1 Three phase half wave converter drive. 3.2.2 Three phase semi converter drive. 3.2.3 Three phase full converter drive. 3.2.4 Three phase dual converter drive. 3.3 Basic chopper circuit using SCR. 3.4 Classification of chopper based on output voltage and quadrant operation. 3.5 Classification of chopper based on quadrant operation. 3.5.1 Class A Chopper Drive. 3.5.2 Class B Chopper Drive. 3.5.3 Class C Chopper Drive. 3.5.4 Class D Chopper Drive. 3.5.5 Class E Chopper Drive. 3.6 Application of chopper control drive in solar and battery powered electric vehicle (Block diagrams only)	Model Demonstration Video Demonstrations Demonstration Flipped Classroom Lecture Using Chalk-Board Site/Industry Visit
4	TLO 4.1 Explain the working of stator voltage control by using AC voltage controller. TLO 4.2 Describe the fundamental principle and working of Variable Frequency Drive (VFD). TLO 4.3 Describe variable frequency control of 3-phase induction motor using VSI. TLO 4.4 Describe sinusoidal PWM technique in AC drives. TLO 4.5 Describe variable frequency control of 3-phase induction motor using CSI. TLO 4.6 Describe given type of slip power recovery control of Three phase induction motor. TLO 4.7 Describe rotor resistance control for 3-phase slip ring induction motor. TLO 4.8 Explain the advantage of using soft starters for starting and speed control of induction motor.	**Unit - IV AC Drives** 4.1 Stator voltage control using AC voltage controller. 4.2 Variable Frequency Control (VFD). 4.3 Voltage Source Inverter Control. 4.4 AC drives using sinusoidal PWM technique. 4.5 Current Source Inverter Control. 4.6 Basics of Slip power recovery - static Kramer drive and static Scherbius drive. 4.7 Rotor Resistance Control. 4.8 Soft starters - Need, significance and working.	Demonstration Video Demonstrations Model Demonstration Flipped Classroom Site/Industry Visit Lecture Using Chalk-Board

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
5	TLO 5.1 State different types of servo motor along with its advantages. TLO 5.2 Describe with sketches the working of servo motor drives for given applications. TLO 5.3 Describe with sketches the working of BLDC motor drives. TLO 5.4 Describe the working of PLL in DC drive TLO 5.5 Describe the working of microcontroller controlled AC/DC drive. TLO 5.6 Describe the method to control step angle and speed of stepper motor using microcontroller. TLO 5.7 Describe the speed control of AC/DC motor drive using PLC.	**Unit - V Advanced Techniques for Motor Control** 5.1 Servo motor drive – introduction, working principle, types, advantages, disadvantages. 5.2 Applications of servo motor drive with block diagram:- Robotics, CNC machine. 5.3 BLDC motor drive - Introduction, Basic building block diagram, Application. 5.4 Phase Locked Loop (PLL) control for DC Motor. 5.5 AC/DC drive using microcontroller control. 5.6 Microcontroller based stepper motor control. 5.7 PLC controlled AC/DC motor drives.	Demonstration Lecture Using Chalk-Board Presentations Video Demonstrations Site/Industry Visit Model Demonstration

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Identify and explain the function of various parts of a DC drive system.	1	*Identification of various parts of DC drive.	2	CO1
LLO 2.1 Identify and explain the function of various parts of an AC drive system.	2	Identification of various parts of AC drive.	2	CO1
LLO 3.1 Control speed of DC shunt motor using single phase half wave-controlled converter. LLO 3.2 Plot torque speed characteristics of the DC shunt motor. LLO 3.3 Plot torque- current characteristics of the DC shunt motor.	3	*Speed control of DC shunt motor using single phase half wave-controlled converter.	2	CO3
LLO 4.1 Control speed of DC shunt motor using single phase full wave converter LLO 4.2 Plot torque speed characteristics of the DC shunt motor. LLO 4.3 Plot torque- current characteristics of the DC shunt motor.	4	*Speed control of DC shunt motor using single phase full wave converter.	2	CO3
LLO 5.1 Control speed of DC shunt motor using single phase semi converter. LLO 5.2 Plot torque speed characteristics of the DC shunt motor. LLO 5.3 Plot torque- current characteristics of the DC shunt motor.	5	Speed control of DC shunt motor using single phase semi converter.	2	CO3

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 6.1 Control the speed of DC shunt motor by armature voltage control method using step down chopper. LLO 6.2 Plot torque- current characteristics of the DC shunt motor. LLO 6.3 Plot torque- Speed characteristics of the DC shunt motor.	6	Speed control of DC Shunt motor by armature voltage control method using step down chopper.	2	CO3
LLO 7.1 Control speed of DC series motor by armature voltage control method using step down chopper. LLO 7.2 Plot torque speed characteristics of DC series motor. LLO 7.3 Plot torque current characteristics of DC series motor.	7	Speed control of DC series motor by armature voltage control method using step down chopper.	2	CO3
LLO 8.1 Control the speed of three phase squirrel cage induction motor by varying stator voltage using thyristor circuit. LLO 8.2 Plot torque speed characteristics of three phase squirrel cage induction motor.	8	Speed control of three phase squirrel cage induction motor using stator voltage control. (Thyristor circuit)	2	CO4
LLO 9.1 Speed control of three phase squirrel cage induction motor using Variable frequency Drive (VFD). LLO 9.2 Plot torque speed characteristics of three phase squirrel cage induction motor	9	*Speed control of three phase squirrel cage induction motor using VFD.	2	CO4
LLO 10.1 Control the speed of three phase slip ring induction motor using rotor resistance control method. LLO 10.2 Plot torque speed characteristics of three phase Slip ring induction motor.	10	*Speed control of three phase slip ring induction motor using rotor resistance control method.	2	CO4
LLO 11.1 Test the performance of v/f control based induction motor drive	11	*Soft start and control the speed of single/three phase induction motor by varying supply frequency using VSI and maintaining constant v/f ratio.	2	CO4
LLO 12.1 Identify parts of BLDC motor drive. LLO 12.2 Connect the parts of BLDC motor drive.	12	Connection of different parts of BLDC drive after identifying its different parts.	2	CO5
LLO 13.1 Control the speed of DC shunt motor using microcontroller. LLO 13.2 Plot torque speed characteristics of DC shunt motor LLO 13.3 Plot torque current characteristics of DC shunt motor	13	Speed control of DC shunt motor using microcontroller drive.	2	CO5
LLO 14.1 Control the speed of DC motor using Programmable Logic Controller(PLC).	14	*Speed control of DC motor using PLC.	2	CO5
LLO 15.1 Perform Plugging operation on given induction motor	15	* Perform Plugging operation on given induction motor	2	CO2

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

Micro project

- Identify drive system in an amusement park and submit report on it.
- Build Step down chopper to control the speed of a small rating DC series motor.
- Build single phase full wave converters for speed control of a small rating DC shunt motor
- Design drive mechanism of a battery-operated bicycle of rating 24V/36V/48V, 250W/500/W/1000W using Brushless DC motor.
- Build Step down chopper to control the speed of 3 phase squirrel cage IM using Rotor Resistance control.
- Prepare a case study on energy efficient electric drive which uses DOL/ Star delta/ Auto transformer/soft starters
- Build a project to control the speed of existing motor in your lab using a Variable Frequency Drive.
- Design drive mechanism for stepper motor.
- Design a control system for a solar tracker that adjusts the position of solar panels to maximize energy harvesting throughout the day.
- Implement a system for controlling the position of a servo motor using a microcontroller.

Assignment

- Analyze factors affecting the efficiency of electric drive systems and propose methods to enhance performance, considering aspects like energy losses and thermal management.
- Examine the challenges and solutions associated with integrating electric drive systems with renewable energy sources such as wind turbines or solar panels
- Investigate the integration of chopper-controlled drives in solar and battery-powered electric vehicles and make report on it.
- Explain the basic principles of electric drives, including the relationship between torque, speed, and position in electric motors.
- Compare single-phase and three-phase converter configurations (half-wave, semi, full, and dual converters) in DC motor control.
- Explain how chopper-controlled drives facilitate regenerative braking in electric vehicles.

Visit

- Visit nearby market to carry out a Survey and submit a report on available choppers, inverters, dual converters for various drives used in our day-to-day life.
- Visit any one sugar/ paper/Steel/ textile mill or other to know the types of drives used in each stage of operation and submit a report on it.
- Visit nearby Industry having advanced technique for controlling speed of DC/AC motor. Prepare report of visit with special comments of AC/DC motor and semiconductor switches used.

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Microcontroller based trainer kit, Microcontroller based Embedded system, DC motor/three phase IM, LDR sensor, LED Series Interface	11,12
2	Open-Source software (MATLAB, SCILAB)	11,12
3	Brushless DC motor	12
4	PLC trainer kit	14
5	DC shunt motor (0.25HP to 1HP),	3,4,5,6,11
6	Dual channel CRO 25 MHZ with Isolation Transformer or power scope, attenuator probe for CRO	3,4,5,6,7,8
7	Experimental Thyristor trainer Kits Choppers, Inverters, Dual Converters, Induction heating, Dielectric heating and connecting cords.	3,4,5,6,7,8,1,2
8	Digital Multimeter 3 1/2-digit, 0-800 volts, 0-10 A, micro ammeter: 0-100 micro ampere	3,4,5,6,8,13,11,12
9	DC Series motor (0.25HP to 1HP),	7,1
10	Resistive load Lamp-100W, Heater Coil-500W	7,8
11	Three phase AC supply 440 V, 10A, 50 Hz	8,9,10,14,11
12	Three Phase Induction Motor (Squirrel Cage and Slip ring Induction Motor) (0.25HP to 1HP)	8,9,12,15
13	Variable frequency Drive (VFD) - 440V ,10A, PWM control Technique.	9
14	Single phase AC supply 230V, 10 A	All

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Basics of Electric Drives	CO1	7	2	4	6	12
2	II	Braking of Electric Motors	CO2	6	2	4	4	10
3	III	DC Drives	CO3	13	4	6	10	20
4	IV	AC Drives	CO4	12	4	6	6	16
5	V	Advanced Techniques for Motor Control	CO5	7	2	4	6	12
Grand Total				**45**	**14**	**24**	**32**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- For formative assessment of theory, two offline unit tests of 30 marks are to be conducted and average of both unit test marks will be considered for out of 30 marks. For formative assessment of laboratory learning, 25 marks are to be considered. Each practical will be assessed considering 60% weightage to process and 40% weightage to product.

Summative Assessment (Assessment of Learning)

- For summative assessment of theory, End semester assessment of 70 marks. For summative assessment of laboratory learning, 25 marks are considered.

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	3	2	1	-	-	-	3			
CO2	3	2	1	1	-	-	3			
CO3	3	3	2	3	1	3	3			
CO4	3	3	2	3	-	2	3			
CO5	3	3	2	3	1	3	3			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	G. K. Dubey	Fundamentals of Electrical Drives	Narosa Publishing House, ISBN: 978-81-7319-428-3
2	D. P. Kothari and Rakesh Singh Lodhi	Electric Drives	WILEY India Edition ISBN:978-9384588120
3	Srinivas Vemula and Ramaiah Veerlapati	Control of DC and AC Drives	Lap lambert academic publishing ISBN: 9783330053434
4	M.H. Rashid	Power Electronics devices circuits and applications	Pearson/Prentice Hall, 2004 ISBN:9780131011403
5	B. N. Sarkar	Fundamentals of Industrial Drive	PHI Learning Pvt. Ltd. ISBN:9788120344334
6	P.C SEN	Thyristor DC Drives	Wiley–Blackwell ISBN: 978-0471060703
7	P.S.Bimbhra	Power Electronics	Khanna Publishers ISBN:978-8174092793

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://nptel.ac.in/courses/108108077	Electric Drives
2	https://archive.nptel.ac.in/courses/108/104/108104140/	Fundamentals of Electric drives
3	http://www.ndl.gov.in/he_document/nptel/nptel/courses_108_104_108104140_video_lec16	Fundamentals of Electric drives

INDUSTRIAL DRIVES AND CONTROL **Course Code : 316330**

Sr.No	Link / Portal	Description
4	https://www.youtube.com/watch?v=pjwXSoOGXiE	Three phase fully controlled converter fed seperately excited DC motor
5	https://www.youtube.com/watch?v=VnAg5kfjFdo	Idea of VVVF Speed Control of Induction Motor
6	https://www.youtube.com/watch?v=dWQLNIbX8aM	Two quadrant chopper and Four Quadrant chopper for motor control
7	https://en.wikibooks.org/wiki/Power_Electronics	Solid state devices and soft starters.
8	https://www.youtube.com/watch?v=ww5uXJ38fqQ	Introduction to Speed Control

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students

POWER SYSTEM ANALYSIS **Course Code : 316331**

Programme Name/s : **Electrical Engineering/ Electrical Power System**

Programme Code : **EE/ EP**

Semester : **Sixth**

Course Title : **POWER SYSTEM ANALYSIS**

Course Code : **316331**

I. RATIONALE

Power system Analysis is a core subject in electrical engineering, which includes transmission line parameters calculations, Power flow analysis analytically & graphically and load flow study. The Electrical Engineering diploma pass outs working in power sector should be able to analyze transmission lines performance with the concept of 'Generalized Circuit theory'. They should also be able to control and maintain voltages and other parameters like active and reactive power flow on different buses of power system at desired level. This course is important for diploma electrical engineers who wish to work in power generation, transmission and distribution companies to handle different activities in power system.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help the student to attain the following industry-identified competency through various teaching-learning experiences ;

- **Analyze the performance of power system networks**.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Calculate Inductance and Capacitance for different types of transmission lines.
- CO2 - Use generalized circuit theory principles for calculations of transmission line performance
- CO3 - Estimate the power at sending and receiving ends of transmission line.
- CO4 - Analyze the performance of transmission lines graphically
- CO5 - Interpret the data required for Load flow studies

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme												
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical							
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
316331	POWER SYSTEM ANALYSIS	PSA	DSE	3	-	2	1	6	3	3	30	70	100	40	25	10	25#	10	25	10	175

Total IKS Hrs for Sem. : Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Explain the significance of analysing the given power system. . TLO 1.2 Describe role of power system engineer for analysing the given power system. TLO 1.3 Describe the impact of given parameter in transmission line performance. TLO 1.4 Develop the equation for inductance/capacitance of the given transmission line TLO 1.5 Calculate inductance / capacitance of the given single-phase line with given configuration TLO 1.6 Evaluate Self Geometric Mean Distance(GMD) and Mutual GMD for the given conductor configuration. TLO 1.7 Estimate the inductance/capacitance of three phase line for the given conductor arrangement. TLO 1.8 Estimate the capacitance of line by considering effect of earth field	**Unit - I Transmission Lines Components** 1.1 Aspects of power system analysis and Role of power system engineer. 1.2 Significance of Transmission line Components –Resistance, Inductance, Capacitance and Conductance 1.3 Inductance-Single phase line composed of solid conductors and bundled conductors. 1.4 Geometric Mean Distance (GMD) - Concept of Self GMD and Mutual GMD 1.5 Inductance of three phase line (single circuit) composed of solid conductors with symmetrical and asymmetrical spacing. 1.6 Concept of Potential difference between two conductors placed in a group of parallel conductors , Capacitance of single-phase line composed of solid Conductors and Duplex bundled conductors. 1.7 Capacitance of three phase line (single circuit) with symmetrical and asymmetrical spacing 1.8 Effect of earth field on transmission line capacitance.by method of Images	Lecture Using Chalk-Board Flipped Classroom Case Study Presentations

POWER SYSTEM ANALYSIS **Course Code : 316331**

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
2	TLO 2.1 Explain the concept of generalized circuit for the given type transmission line. TLO 2.2 Calculate the Generalized Circuit Constants (GCC) for the given type transmission line. TLO 2.3 Develop resultant generalized network of the given type combination of networks. TLO 2.4 Describe the benefits of generalised circuit representation of the given type of transmission line.	**Unit - II Generalized circuit representation** 2.1 Generalized Circuit – Concept. 2.2 Generalized circuit constants (GCC) of short, medium transmission line. 2.3 Generalized circuit constants (GCC) of two networks connected in series. 2.4 Generalized circuit constants (GCC) of two networks connected in parallel. 2.5 Advantages of Generalized circuit representation.	Lecture Using Chalk-Board Flipped Classroom Case Study Presentations
3	TLO 3.1 Explain the concept of complex power with reference to the given power system. TLO 3.2 Develop the expression for complex power at given end of the given transmission line. TLO 3.3 Calculate the real/reactive power at given end of given transmission line for the given loading condition. TLO 3.4 Derive the condition for maximum real power flow of given end of the given transmission line	**Unit - III Power flow** 3.1 Complex Power (S=V I*), Real Power and reactive Power. 3.2 Derivation for Complex power, real power, reactive power for receiving end of the transmission line using Generalized Circuit Equation (GCE). 3.3 Derivation for Complex power, real power, reactive power for sending end of the transmission line using Generalized Circuit Equation (GCE). 3.4 Condition for maximum power at receiving end of transmission line. 3.5 Condition for maximum power at sending end of transmission line	Lecture Using Chalk-Board Flipped Classroom Case Study Presentations Video Demonstrations
4	TLO 4.1 Describe the locus of complex power flowing through transmission line at both end TLO 4.2 Draw locus of complex power at receiving end transmission line with given loading condition and evaluate performance parameters. TLO 4.3 Draw locus of complex power at Sending end transmission line with given condition and evaluate performance parameters. TLO 4.4 State the Advantages of graphical analysis by using Circle diagram.	**Unit - IV Line performance by graphical analysis** 4.1 Graphical method for Transmission line performance analysis- circle diagram , Receiving end and Sending end circle diagram 4.2 Procedure to draw circle diagram for Receiving end and derive performance parameter. 4.3 Procedure to draw circle diagram for Sending end and derive performance parameter. 4.4 Transmission line performance parameters calculations by drawing circle diagram. 4.5 Advantages of graphical analysis by using Circle diagram.	Lecture Using Chalk-Board Flipped Classroom Case Study Presentations Video Demonstrations

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
5	TLO 5.1 Explain the significance of Load flow analysis for the given power system. TLO 5.2 State the data required for Load flow studies for the given power system. TLO 5.3 Interpret the Characteristics' of the given SLFE for specified power system TLO 5.4 Identify the information obtained from the given Load flow study. TLO 5.5 Identify significant features of the given Ybus matrix TLO 5.6 Develop Ybus matrix for given 3 bus system.	**Unit - V Load flow studies** 5.1 Load flow studies- Concept and its need. 5.2 Data required for Load flow studies. 5.3 Static Load Flow Equation (SLFE) for simple two bus system and definition of parameters (only equation). 5.4 Characteristics of SLFE. 5.5 Information obtained from Load Flow Studies 5.6 Formation of Ybus (for 3 bus system including reference bus).	Lecture Using Chalk-Board Flipped Classroom Case Study Presentations Video Demonstrations

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Identify type of conductor from given sample of line conductors. LLO 1.2 Calculate self GMD.	1	*Identification of type of conductors and calculate Self GMD.	2	CO1
LLO 2.1 Evaluate Inductance for 3 ø transmission line with symmetrical and unsymmetrical spacing. LLO 2.2 Evaluate capacitance for 3 ø transmission line with symmetrical and unsymmetrical spacing.	2	*Inductance and capacitance for 3 Ø transmission line with symmetrical and unsymmetrical spacing.	2	CO1
LLO 3.1 Evaluate Inductance and capacitance for 1 ø transmission line without ground effect and with ground effect. LLO 3.2 Evaluate Inductance and capacitance for 1 ø transmission line without ground effect and with ground effect.	3	Inductance and capacitance for 1ø transmission line without ground effect and with ground effect.	2	CO1
LLO 4.1 Perform OC and SC Test and evaluate Generalized circuit constant (GCC) of given n model of transmission line.	4	*GCC of given n model of transmission line. by using OC SC test.	2	CO2
LLO 5.1 Perform OC and SC Test and evaluate Generalized circuit constant (GCC) of given T model of transmission line.	5	GCC of given T model of transmission line by using OC SC test.	2	CO2
LLO 6.1 Determine Generalized circuit constant (GCC) of given n (PI) model of transmission line by using Scilab.	6	*GCC of given n (PI) model of transmission line by using software.	2	CO2
LLO 7.1 Determine Generalized circuit constant (GCC) of given T model of transmission line by using Scilab	7	GCC of given T model of transmission line by using software.	2	CO2
LLO 8.1 Perform Load test on given n (PI) model of transmission line and determine the Efficiency and regulation.	8	n (PI) model Transmission line Efficiency and regulation by Load test.	2	CO3
LLO 9.1 Perform Load test on given T model of transmission line and determine the efficiency and regulation.	9	*T model Transmission line Efficiency and regulation by Load test.	2	CO3

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 10.1 Evaluate Receiving end complex power by using Scilab for given transmission line under load condition.	10	Transmission line Receiving end complex power evaluation by using software.	2	CO3
LLO 11.1 Evaluate Sending end complex power by using Scilab for given transmission line under given condition.	11	Transmission line Sending end complex power evaluation by using software.	2	CO3
LLO 12.1 Draw Circle Diagram for Receiving end or Sending end for given transmission line under load condition by using scilab / MATLAB.	12	*Transmission line Receiving end or Sending end complex power evaluation by graphical method.	2	CO4
LLO 13.1 Use Scilab / MATLAB to develop Ybus matrix for given 3- bus system-1.	13	*Development of Ybus matrix by using software- case 1.	2	CO5
LLO 14.1 Use Scilab / MATLAB to develop Ybus matrix for given 3- bus system-2.	14	Development of Ybus matrix by using software- case 2.	2	CO5
LLO 15.1 Determine the effect on SLFE for given power system using relevant software like VLAB	15	Determination of effect on SLFE during the maintenance outages for given power system using relevant software.	2	CO5

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

Assignment

- Calculate inductance and capacitance / km and total loop Inductance of the given 1 ø line / 3 ø line with symmetrical/ unsymmetrical spacing with / without considering ground effect. Vary spacing / size of conductor and observe effect on line parameters.
- A 3 ø line with given equilateral spacing is to be rebuilt with horizontal/vertical spacing as D13 = 2D12 = 2D23. The conductors are to be fully transposed. Find the spacing between adjacent conductor such as that new line has the same inductance as original value.
- Determine ABCD constants, calculate sending end voltage and percentage regulation for 3 ø transmission line with given impedance and admittance and for given loading condition by Using n / T method.
- For given ABCD constants and line details with load condition, determine Sending end power / receiving end power and maximum power that can be delivered Analytically and graphically
- For given ABCD constants and for given loading condition, calculate performance of line - sending end voltage, sending end current, voltage regulation and efficiency by Using n / T method

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Sample of transmission line conductors	1
2	AC ammeter 2.5A, 5A	4,5,8,9
3	AC voltmeter 30V, 300V	4,5,8,9
4	Single Phase Wattmeter –Lpf 2.5A,300 V and unity pf 5A ,75/300V	4,5,8,9
5	Single Phase Auto transformer 0-250 V,10A	4,5,8,9
6	Simulation n model of transmission line or trainer kit	4,8
7	Simulation T model of transmission line or trainer kit.	5,7
8	Open source software ?Scilab 5.5.2 (any other suitable software)	6,7,10,11,12,13,14,15
9	Lamp Bank 1kW, 230 V, 5A	8,9

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Transmission Lines Components	CO1	16	4	7	7	18
2	II	Generalized circuit representation	CO2	8	2	7	4	13
3	III	Power flow	CO3	7	2	4	8	14
4	IV	Line performance by graphical analysis	CO4	8	2	6	7	15
5	V	Load flow studies	CO5	6	2	6	2	10
Grand Total				**45**	**12**	**30**	**28**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Two unit tests of 30 marks will be conducted and average of two unit tests considered
- For formative assessment of laboratory learning 25 marks.
- For formative assessment of laboratory learning 25 marks. Each practical will be assessed considering appropriate % weightage to process and product and other instructions of assessment.

Summative Assessment (Assessment of Learning)

- End semester summative assessment of 25 marks for laboratory learning.
- End semester assessment of 70 marks through offline mode of examination.

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	2	3	3	2	2	2	3			
CO2	2	3	2	2	2	2	3			

CO3	3	3	2	2	2	2	3			
CO4	2	3	3	3	2	2	2			
CO5	2	2	2	2	2	2	3			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Mehta V. K ; Mehta Rohit	Principles of Power System	S.Chand and Co., New Delhi. . 3rd Edition ISBN-10. 9788121924962 · ISBN-13. 978-8121924962
2	Nagrath I. J. Kothari D. P.	Modern Power System Analysis	McGraw HillEducation, New Delhi 5th Edition. 14 June 2022. ISBN-13: 978-9354600968
3	Stevenson William	Elements of Power System Analysis	McGraw-Hill Book Company, New York, 2014(4th addition) ISBN 10: 0070612781 / ISBN 13: 9780070612785
4	Wadhava C. L.	Electrical Power System	New age international publishers ISBN: 13-978-1-4987-7757-5-(EPUB)
5	Gupta B.R.	Power system Analysis and Design	S. Chand and Co. Ltd., New Delhi Edition: 6 Year: 2011 ISBN: 81-219-2238-0

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://archive.nptel.ac.in/courses/117/105/117105140/	NPTEL Lecture series on power system Analysis
2	https://archive.nptel.ac.in/courses/108/105/108105067/	Lecture series on Transmission line components calculation, load flow studies & Y bus formation.
3	https://www.youtube.com/watch?v=wuT2fqdT2pE	Basics of load flow study
4	https://srmeeevlab.github.io/PSA/3_Formation_of_Bus_admittance_Matrix_(without_mutual_coupling)/simulation.html	Exercises on Y bus & Z bus matrix formation by using VLAB

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students