SHIVAJI UNIVERSITY, KOLHAPUR - 416 004,
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शिवाजी विद्यापीठ, कोल्हापूर - ४१६ ००४, महाराष्ट्र
दूरध्वनी - ईपीएबीएक्स - २६०९०००, अभ्याससमंडळे विभाग दुरध्वनी विभाग ०२३१–२६०९०९३/९४

Estd. 1962
"A++" Accredited by NAAC(2021)
With CGPA 3.52

SU/BOS/Sci & Tech/470 **Date : 26/06/2023**

To,

1) The Director,
Departments of Technology,
Shivaji University, Kolhapur

2) The Principal/ Director,
All affiliated Engineering Colleges/ Institute,
Shivaji University, Kolhapur.

Subject: Regarding revised syllabus of **Ph. D. Coursework** under the Faculty of Science and Technology.

Sir/Madam,

With reference to the subject mentioned above, I am directed to inform you that the university authorities have accepted and granted approval to the syllabus of **Ph. D. Coursework** under the Faculty of Science and Technology.

1.	Civil Engineering & Technology
2.	Mechanical Engineering & Technology
3.	Electrical Engineering & Technology
4.	Electronics Engineering & Technology
5.	Electronics and Telecommunication Engineering & Technology
6.	Textile Engineering & Technology
7.	Computer Science Engineering & Technology
8.	Environmental Engineering & Technology
9.	Pharmacy

This syllabus will be implemented from the academic year 2023-24 i.e. from June 2023 onwards.

You are therefore, requested to bring this to the notice of all students and teachers concerned.

Thanking you,

Yours faithfully,

Dr. S. M. Kubal
Dy. Registrar

Copy to:

1	The Dean, Faculty of Science & Technology	7	Computer Centre (IT)
2	The Chairman, Respective Board of Studies	8	Affiliation Section (T.1)
3	Director, Examination and Evaluation	9	Affiliation Section (T.2)
4	Eligibility Section	10	P.G.Admission Section
5	O.E. – 4	11	P.G Seminar Section
6	Appointment Section	12	Meeting Section

Shivaji University, Kolhapur

Ph.D. Course Work

Course Structure

ELECTRICAL ENGINEERING

Paper No.	Course Title	Marks
I	Research Methodology, Quantitative Techniques and Computer Application.	100
II	Advances in Electrical Engineering	100
III	Elective Courses (Based on Specialization). (The student has to select one Elective from the following Course) 1. Electric and Hybrid Electric Vehicles 2. Advanced Power System for Grid Resilience 3. Power System Protection	100
	Total Marks	300

Examination Scheme:

Course Paper I: Research Methodology, Quantitative Techniques and Computer Application - This is a common Course for the Faculty of Engineering and its scheme of examination is also common.

For Paper II & III, the theory Examination will be of 100 Marks. With passing of minimum 50 Marks each.

Paper No.	Course Title	Theory marks
Paper II	Advances in Electrical Engineering	100
Paper III	Elective	100

Course Name: **Electric and Hybrid Electric Vehicles (**Elective)

Course Description:
This course is an elective course in Electrical Engineering. This course introduces the fundamental concepts, principles, and analysis of electric and hybrid electric vehicles.

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

1. Discuss Conventional Vehicles and Powertrains
2. Analyse the electric drive mechanism.
3. Investigate Battery Management Systems
4. Classify hybrid electric vehicles
5. Describe plug-in hybrid electric vehicles and electrical infrastructure.

Pre requisite: Electric machines, Power electronics, Power Systems

Course Content		
Unit No.	**Description**	**Hrs.**
1	**Introduction to Electric Vehicles:** What Is an Electric Vehicle? Engineering philosophy of EV development, Overview of EV Challenges, Pure Electric Vehicle, Hybrid Electric Vehicle, Gridable Hybrid Electric Vehicle, Fuel-Cell Electric Vehicle, Overview of EV Technologies, Motor Drive Technology Energy Source Technology, Battery Charging Technology, Vehicle-to-Grid Technology	**07**
2	**Fundamentals of Vehicles and Powertrains:** EV configurations, EV Parameters, Longitudinal Vehicle Model, Longitudinal Resistance, Total Tractive Force, Maximum Tractive Effort and Powertrain Tractive Effort, Vehicle Performance, Braking Performance and Distribution, Vehicle Power Plant and Transmission Characteristics	**07**
3	**Electric Propulsion Machines:** Machine specifications, DC Machine, equivalent circuits and equations, Using DC Machine for EV Powertrain, Permanent Magnet Brushless Motor Drives, Surface-Permanent-Magnet AC Machines, Interior-Permanent-Magnet AC Machine, Switched Reluctance Motor Drives, Applications of drives in EV.	**07**
4	**Battery Management Systems in Electric Vehicles:** Basic definitions, SOC Estimation methods, and Battery Management System: Definition, Parts: Power Module, Battery, DC/DC Converter, Battery System Balancing, Centralized BMS, Distributed BMS, communication channel, Safety in Battery Design, Battery Pack Safety, Battery Standards & Tests, Practical examples of BMS, BMSs in Future Generation	**07**
5	**Hybrid Electric Vehicles:** Introduction to Hybrid Electric Vehicles and Hybrid Electric Powertrains, series hybrid, parallel hybrid, power split hybrid, Introduction to Hybrid Powertrain Components, Regenerative Braking Systems, Introduction to Hybrid Powertrain Controls, Driving Cycles and road conditions, fuel economy, HEV Technologies, Classification Based on Their Powertrain System, Challenges in HEV	**06**

	Design and Realization, Plug-In Hybrid Electric Vehicles.	
6	**Plug-in Hybrid Electric Vehicles and Electrical Infrastructure:** Introduction, Components of PHEVs, Operating Principles of Plug-in Hybrid Vehicle, Plug-In Hybrid Vehicular Architecture, Fuel Economy of PHEVs, power management, component sizing, Control Strategy of PHEV, PHEV-Related Technologies and Challenges, PHEV Market, EV and PHEV charging infrastructures , Requirements of EV/PHEV Batteries, power electronics for PEV charging, grid tied home and public systems, EV battery charging specifications and safety issues, charging modes, V2G and V2G technology. impact of Charging and V2G power flow on the grid	**06**

Text Books:

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press
2. Ali Emad, Advanced Electric Drive Vehicles - CRC Press
3. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press.

Reference Books:

1. K. T. Chau, Electric vehicle Machines and drives Design, analysis and application, Wiley
2. John G Hayes, G Abas Goodrazi, Electric Powertrain Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles, John Wiley & Sons
3. C. C. Chan, K. T. Chau - Modern Electric Vehicle Technology, Oxford University Press

Course Name : **Advanced Power System for Grid Resilience (**Elective)

Course Description: The course on Advanced Power System for Grid Resilience aims to provide in-depth knowledge and understanding of the various aspects of power systems and their resilience in the face of grid disturbances and challenges. The course is designed specifically for PhD students in the field of electrical engineering, focusing on advanced topics related to power system analysis, control, and protection for grid resilience

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

1. Understand Power System Transients
2. Analyze Transient Effects
3. Evaluate Grid Resilience
4. Investigate Case Studies

Prerequisite: Power system, Electric Circuit Analysis and Mathematics.

Course Content		
Unit No.	**Description**	**Hrs**
1	Introduction to Power System Resilience • Definition and importance of power system resilience • Key challenges and vulnerabilities in power grids • Frameworks and metrics for assessing grid resilience	**06**
2	Power System Modeling and Analysis • Power system components and their mathematical representation • Power flow analysis and optimization techniques • Stability analysis: transient, voltage, and frequency stability • Harmonic analysis and mitigation strategies	**07**
3	Power System Oscillations • Overview of Sub synchronous oscillations (SSO) and its classification • Analysis of renewable energy systems • Impact of series compensation on SSO • Damping methods using advanced control system	**07**
4	Grid Integration of Renewable Energy Sources • Impact of renewable energy sources on grid resilience • Grid codes and standards for renewable energy integration • Power quality issues and solutions • Battery energy storage for grid resilience	**07**
5	Case Studies and Real-World Applications • Analysis of grid resilience in response to natural disasters and cyber-attacks • Case studies of power system oscillations and their impact on grid resilience	**07**

	• Evaluation of resilience-enhancing strategies in power grids • Role of advanced technologies in enhancing grid resilience	
6	Research Trends and Future Directions • Emerging technologies and trends in power system resilience • Research challenges and opportunities in the field • Discussion on ongoing research projects and advancements	**06**

Text Books:

1. J. Duncan Glover, Mulukutla S. Sarma, and Thomas Overbye, “Power System Analysis and Design"
2. Juan A. Martinez-Velasco, “Power System Transients: Parameter Determination"
3. Eiichi Haginomori, Tadashi Koshiduka, Junichi Arai, and Hisato Fujisawa, “Transient Analysis of Power Systems: A Practical Approach"
4. Akihiro Ametani, Naoto Nagaoka, and Teruo Ohno, ”Power System Transients: Theory and Applications"

Reference Books:

1. Prabha Kundur , “Power System Stability and Control"
2. Peter W. Sauer and M. A. Pai, “Power System Dynamics and Stability"
3. Akihiro Ametani, Naoto Nagaoka, and Teruo Ohno , “Electromagnetic Transients in Power Systems"

Course Name: **Power System Protection (**Elective)

Course Description:
Modern power system protection systems are extensively using digital techniques for realizing various needs of protection. This course will strengthen the concepts in power system protection and develop the skills necessary to analyze, design and implement digital protective relays.

Course Learning Outcomes:
After learning the course the students should be able to:
1. Study of numerical relays
2. Developing mathematical approach towards protection
3. Study of algorithms for numerical protection.

Pre requisite: Electrical Protection, Power Systems.

Course Content		
Unit No.	**Description**	**Hrs.**
1	**Numerical Protection** Introduction, block diagram of numerical relay, sampling theorem, correlation with a reference wave, least error squared (LES) technique, digital filtering, and numerical over- current protection.	**06**
2	**Estimation of Phasors:** Estimation of phasors using Full cycle Discrete Fourier Transform (DFT), Estimation of phasors using Half cycle DFT and introduction of Discrete Cosine Transform, Estimation of phasors using Walsh function technique and Least Error Square technique, Estimation of frequency in digital relays and practical considerations for selection of various algorithms.	**07**
3	**Relay coordination of Interconnected Power System**: Protection of an interconnected system, Link net structure, Flowchart ofprimary/Backup relay pairs, Flowchart of Time Multiplier Setting. Examples based on existing power system network.	**06**
4	**Reclosing and Synchronizing**: Introduction, Reclosing Precautions, Reclosing System Consideration, One-Shot vs. Multiple-Shot Reclosing Relays, Selective Reclosing, Deionizing Times for Three-Pole Reclosing, Live-Line/Dead-Bus, Live-Bus/Dead-Line Control Instantaneous-Trip Lockout, Intermediate Lockout, Factors Governing Application of ReclosingConsiderations for Applications of Reclosing , Feeders with No-Fault-Power Back-Feed and Minimum Motor Load, Single Ties to Industrial Plants with LocalGeneration, Lines with Sources at Both Ends, Reclosing Relays andTheir Operation, Review of Breaker Operation, Single-Shot ReclosingRelays, Multishot Reclosing Relays, Synchronism Check, PhasingVoltage Synchronism Check Characteristic, AngularSynchronism	**08**

5	**Concept of Different Relay Algorithms**: Introduction of different techniques, Least square based methods, Introduction, Integral LSQ fit, Power series LSQ fit, Differential equation based techniques, Basic principles, Digital harmonic filtering by selected limits, Fourier analysis based techniques, Introduction, The full cycle window algorithm, The half cycle window algorithm	**07**
6	**Application of Artificial Intelligence (AI) in digital relaying**. Applications of Fuzzy Logic and ANN for power system protection, Fault detection, classification and location algorithm, adaptive distance protection, Wide Area Monitoring and Protection.	**06**

Text Books:

1) L. P. Singh , Digital Protection, New Age International Private Ltd. Publishers, New Delhi, 2nd Edition, 1997.
2) Paithankar, Marcel and Dekker, Transmission Network Protection, New York,1997
3) Walter A. Elmore, Marcel Dekker, Protective Relaying Theory and Applications.
4) Power System Protection, IEEE Press, Wiley Interscience, A John Wiley & Sons Inc; New York, 1999- P. M. Anderson

Reference Books:

1) Paithankar & Bhide, Fundamentals of Power System Protection, Prentice Hall of India Pvt Ltd., New Delhi,2010
2) Stanley Horowitz, Protective Relaying for Power System II IEEE press , New York,1992