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४१६ ००४, महाराष्ट्र
दूरध्वनी - इपीबीएक्स - २०६०९०००, अभ्यासमंडळे विभाग : ०२३१- २६०९०९४. २६०९४८७
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जा.क्र./शि.वि/अं.म./ 269 दिनांकः– 12/05/2024

प्रति,

मा. संचालक,
तंत्रज्ञान अधिविभाग,
शिवाजी विद्यापीठ, कोल्हापुर

मा. प्राचार्य/ संचालक,
सर्व संलग्नीत अभियात्रिकी महाविद्यालय व इन्स्टिटयुट,
शिवाजी विद्यापीठ, कोल्हापुर

विषय : सिव्हील पीएच.डी. कोर्सच्या अभ्यासक्रमाबाबत..
संदर्भ : या कार्यालयाचे पत्र क्र.एसयु/बीओएस/सायन्स – टेक/४७० दि.२६/०६/२०२३.

महोदय,

उपरोक्त संदर्भिय विषयास अनुसरुन आपणास आदेशान्वये कळविण्यात येते की, शैक्षणिक वर्ष २०२३–२४ पासून लागू करण्यात आलेल्या **सिव्हल पीएच.डी. कोर्सवर्क** अभ्यासक्रमामध्ये किरकोळ दुरुस्ती करण्यात आलेली आहे. सोबत सदर अभ्यासक्रमाची प्रत जोडली आहे. तसेच विद्यापीठाच्या www.unishivaji.ac.in (Online Syllabus) या संकेतस्थळावर ठेवण्यात आला आहे.

सदर अभ्यासक्रम सर्व संबंधित विद्यार्थी व शिक्षकांच्या निदर्शनास आणून द्यावी ही विनंती.

कळावे,

आपला विश्वासू,

डॉ. एस. एम. कुबल
उपकुलसचिव
अभ्यास मंडळ विभाग

सोबत : अभ्यासक्रमाची प्रत.

प्रत :–

1. अधिष्ठाता, विज्ञान व तंत्रज्ञान विद्याशाखा
2. समन्वयक, कॉम्प्युटर सायन्स इंजिनिअरिंग अभ्यास मंडळ
3. मा. संचालक, परीक्षा व मुल्यमापन मंडळ
4. इतर परीक्षा 4 विभागास.
5. परीक्षक नियुक्ती ए व बी विभागास.

यांना माहितीसाठी व पुढील कार्यवाहीसाठी

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Shivaji University, Kolhapur

Ph.D. Course Work

Course Structure

ELECTRICAL ENGINEERING

Course No.	Course Title	Marks
I	Research Methodology, Quantitative Techniques and Computer Application.	100
II	Power System Optimization	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 80 Marks. Term work 20 marks. With passing of minimum 50 Marks each.

Paper No.	Course Title	Theory marks
Paper II	Power System Optimization	80
Paper III	Elective	80

Course Name: **Power System Optimization**

Course Description:
The power system optimization problems are complex and nonlinear in nature. This course includes the study of power system optimization problems such as unit commitment, economic dispatch, and optimal power flow. This course also highlights the issues with power system optimization problems

Course Learning Outcomes:

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

1. Explain the need of power system optimization.
2. Formulate power system optimization problem.
3. Apply numerical and heuristic technique to solve power system optimization problem.
4. Solve power system optimization problem.
5. Assess the impact of parameters on defined optimization problem.

Prerequisite: Power system, Electric Circuit Analysis and Mathematics.

Course Content

Unit No.	**Description**	**Hrs.**
1	**Fundamental of Optimization:** Definition-Classification of Optimization Problems-Unconstrained and Constrained Optimization, Optimality Conditions-Classical Optimization techniques (Linear and Non-linear Programming, Mixed Integer Programming)-Intelligent Search Methods (Optimization Neural Network, Genetic Algorithms, Particle Swarm Optimization).	**06**
2	**Optimization for Economic Dispatch Problem:** Economic Dispatch Problem, Thermal System Dispatching with Network Losses, The Lambda-Iteration Method, Gradient Methods of Economics Dispatch, and Economic Dispatch by Gradient Search, Newton's Method, Economic Dispatch using Dynamic Programming, and Genetic Algorithms based Economic Dispatch Solution.	**07**
3	**Optimization for Unit Commitment:** Constraints in Unit Commitment, Thermal Unit Constraints, Other Constraints, Hydro-Constraints, Fuel Constraints, Unit Commitment Solution Methods: Priority-List Methods, Dynamic-Programming Solution, Lagrange Relaxation Solution, Particle Swarm Optimization based Unit Commitment, and Genetic Algorithm for Unit Commitment	**07**
4	**Hydrothermal Coordination:** Long-Range Hydro-Scheduling, Short-Range Hydro-Scheduling, Hydroelectric Plant Models, The Short –Term Hydrothermal Scheduling Problem, Short Term Hydro-Scheduling: A Gradient Approach, Hydro –Units in Series (Hydraulically Coupled), Pumped –Storage Hydro-plants, Pumped-	**07**

	Storage Hydro-Scheduling with λ -γ Iteration, Scheduling Problem, Dynamic-Programming Solution to Hydrothermal, Hydro-Scheduling Using Linear Programming Method.	
5	**Optimal Power Flow:** Optimal Power Flow Problem, The Gradient Method, Linear Sensitivity Coefficients of an AC Network Model, Linear Programming Method with only Real Power variables, Non-Linear Programming with AC Power Flow variables and Detailed Cost Functions, Security Constrained Optimal Power Flow, Interior Point Algorithm, Genetic Algorithm based Optimal power flow, Particle Swarm Optimization based Optimal Power Flow Problem.	**07**
6	**Multi-objective Optimization:** Introduction to Multi-objective optimization, Concept of Pareto Optimality, Conventional approaches for Multi-objective Genetic Algorithm, Fitness assignment-Sharing function-Economic Emission dispatch using Multi objective Genetic Algorithm and Multi-objective Particle Swarm Optimization, Multi-objective optimal power problem.	**06**

Text Books:

1. Allen J.Wood and Wollenberg B.F., “Power Generation Operation and Control”, John Wiley & Sons.
2. D.P.Kothari and J.S.Dhillon, “Power System Optimization”, PHI learning private limited.

Reference Books:

1. Olle I Elgard, “Electric Energy systems Theory - An Introduction”, TMH.
2. Jizhong Zhu, “Optimization of power system operation”, John Wiley and sons.
3. SolimanAbdel Hady, Abdel Aal Hassan Mantawy, “Modern optimization techniques with applications in Electric Power Systems”.
4. Kwang Y.Lee,Mohammed A.El Sharkawi, “Modern heuristic optimization techniques”, John Wiley and Sons.

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.

Prerequisite: 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.

Prerequisite:
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