Department of Electrical Engineering

Honors

Title: Honors in Electrical Engineering

Sem	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
III	HON-01	*<tbd>*	Engineering Optimization	3	-	-	1	**3**	30	20	50	--	--
IV	HON-02	*<tbd>*	Electrical Power Distribution Systems	3	-	2	1	**4**	30	20	50	50	50
V	HON-03	*<tbd>*	Modelling and Analysis of Electrical Machines	3	-	2	1	**4**	30	20	50	50	50
VI	HON-04	*<tbd>*	Intelligent Control	3	-	2	1	**4**	30	20	50	50	50
VII	HON-05	*<tbd>*	Advanced Power Electronics	3	-	-	1	**3**	30	20	50	--	--
			Total	**15**	**-**	**06**	**05**	**18**					

Engineering Optimization

Course Code	<tbd>		**Examination Scheme**			
Teaching Scheme	3-0-0-1		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	CIE: --	ESE: --	--

Course Outcomes: Students will be able to:

1. Explain and use the basic theoretical principles of optimization and various optimization techniques.
2. Develop and select appropriate models corresponding to problem descriptions in engineering and solve them correctly.
3. Solve and analyze complex optimization problems in power system/control system/machine drive.
4. Implement various optimization software tools to solve power system/ control system/ machine drive problems and develop algorithms to solve electrical problems.

Unit 1: Introduction	**[7Hrs]**

Introduction to optimization, Statement of an Optimization Problem, Design Vector, Design Constraints, Constraint Surface, Objective Function, Objective Function Surfaces, Classification of Optimization Problems.

Unit 2: Classical Optimization	**[8Hrs]**

Classical Optimization: Single variable optimization, Multivariable optimization with no constraints, Multivariable optimization with equality constraints: Solution by Direct Substitution, Solution by the Method of Lagrange Multipliers, Multivariable optimization with inequality constraints: Kuhn-Tucker Conditions.

Unit 3: Linear Programming	**[9Hrs]**

Introduction, Applications of Linear Programming, Standard Form of a Linear Programming Problem, Geometry of Linear Programming Problems, Solution of a System of Linear Simultaneous Equations, Pivotal Reduction of a General System of Equations, Motivation of the Simplex Method, Simplex Algorithm: Identifying an Optimal Point, Improving a Non optimal Basic Feasible Solution, Duality Theory, Transportation Problem.

Unit 4: Nonlinear Programming	**[8Hrs]**

Introduction, Unimodal Function, Unrestricted Search: Search with Fixed Step Size, Search with Accelerated Step Size, Exhaustive Search, Dichotomous Search, Interval Halving Method, Fibonacci Method, Golden Section Method, Interpolation Methods: Quadratic Interpolation Method, Cubic Interpolation Method, Multivariable Unconstrained Optimization: Steepest Descent Method, Newton's Method.

Unit 5: Dynamic Programming	**[8Hrs]**

Introduction, Multistage Decision Processes, Representation of a Multistage Decision Process Conversion of a Nonserial System to a Serial System, Types of Multistage Decision Problems, Concept of Sub optimization and the Principle of Optimality, Computational Procedure in Dynamic Programming, Conversion of a Final Value Problem into an Initial Value Problem, Linear Programming as a Case of Dynamic Programming, Continuous Dynamic Programming, Introduction to Advanced Optimization Techniques (Genetic Algorithm, Particle Swarm Optimization, Differential Evolution – overview only).

Self-Study (SS):

1. Applications of optimization techniques to power system/control systems/power electronics and machine drives.

Textbooks:

[1]	Singiresu S. Rao, Nitin Kumar and D. Sumitha, "Engineering Optimization: Theory and Practice", 5th Edition (Indian Adaptation), Wiley India Pvt. Ltd., New Delhi, 2023.
Reference Books:	
[1]	R. Fletcher, "Practical Optimization", Second edition, John Wiley and Sons, New York, 1987.
[2]	K. V. Mital and C. Mohan, "Optimization Methods in Operations Research and System Analysis", New age International Publishers, Third edition, 1996.
[3]	M. S. Bazaraa, H. D. Sherali and C. M. Shetty, "Nonlinear Programming: Theory and Algorithms", 4th Edition, John Wiley & Sons, 2013.
[4]	Bertsekas D. P., "Constrained Optimization and Lagrange Multiplier Methods", Academic Press, New York, 1982.
Note:	
[1]	To measure CO1, questions may be of the type- define, identify, state, match, list, name etc.
[2]	To measure CO2, questions may be of the type- explain, describe, illustrate, evaluate, give examples, compute etc.
[3]	To measure CO3, questions will be based on applications of core concepts.
[4]	To measure CO4, questions may be of the type- true/false with justification, theoretical fill in the blanks, theoretical problems, prove implications or corollaries of theorems, etc.
[5]	To measure CO5, some questions may be based on self-study topics and comprehension of unseen passages.

Electrical Power Distribution Systems						
Course Code	<tbd>		**Examination Scheme**			
Teaching Scheme	3-0-2-1		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	4		**Laboratory**	CIE: 50	ESE: 50	--

Course Outcomes: Students will be able to:

1. Calculate load necessary for planning of new distribution systems.
2. Design primary and secondary distribution systems.
3. Analyze unbalanced distribution systems and explain impact of integration of DGs.
4. Address the protection and reliability issues in distribution systems.
5. Design active network configurations.

Unit 1: Introduction of a Distribution System	**[8 Hrs]**
Introduction to Electrical distribution system, Components of distribution system substation and busbar layouts, Components of distribution system and feeder configurations, Nature of loads in a distribution system.	
Unit 2: Methods for Approximate Analysis	**[8 Hrs]**
Load allocation in a distribution system, 'K' Factors and Their Applications, Analysis of Uniformly Distributed Loads, Lumping Loads in Geometric Configurations: Rectangular, Lumping Loads in Geometric Configurations: Triangular, Series Impedance of Distribution Lines and Feeders.	
Unit 3: Components of Distribution System	**[8 Hrs]**
Series Impedance of Distribution Lines and Feeders-Part II, Models of Distribution Lines and Cables, Modeling of Single-Phase, Modeling of Step Voltage Regulators.	
Unit 4: Load Models in Distribution System	**[8 Hrs]**
Load Models in Distribution System, Modeling of Distributed Generation, Applications and modeling of Capacitor Banks, Modeling of distribution system components.	
Unit 5: Load Flow, Fault Analysis, and Grid Applications	**[8 Hrs]**

Backward/Forward Sweep Load Flow Analysis, Direct Approach Based Load Flow Analysis, Direct Approach Based Load Flow Analysis: Weakly meshed system, Direct Approach for short-circuit analysis: Introduction and LG Fault, LL Fault. Applications: Distributed generation integration issues, protection coordination and hazards, power quality, reliability, and availability. Optimization techniques: Optimal location and sizing of battery energy storage systems (BESS), field deployment aspects of BESS, and emerging trends.
Self-Study (SS):
1. Long-term load forecasting methodologies for urban distribution network planning. 2. Technical grid-interconnection standards and the impact of intentional islanding and microgrid protection coordination.

Textbooks:

[1]	W. H. Kersting, Distribution System Modeling and Analysis, 4th ed. Boca Raton, FL, USA: CRC Press, 2017.
[2]	R. C. Dugan and T. E. McDermott, "An open-source platform for collaborating on smart grid research," in Proc. IEEE Power and Energy Society General Meeting, Minneapolis, MN, USA, 2010.

Reference Books:

[1]	R.E. Brown, "Electric Power Distribution Reliability (2nd ed.)," CRC Press, 2009.
[2]	Pabla, "Electric Power Distribution: Sixth Edition," McGraw-Hill Professional, New York, 2011.

Note:

[1]	To measure CO1, questions may be of the type- define, identify, state, match, list, name etc.
[2]	To measure CO2, questions may be of the type- explain, describe, illustrate, evaluate, give examples, compute etc.
[3]	To measure CO3, questions will be based on applications of core concepts.
[4]	To measure CO4, questions may be of the type- true/false with justification, theoretical fill in the blanks, theoretical problems, prove implications or corollaries of theorems, etc.
[5]	To measure CO5, some questions may be based on self-study topics and comprehension of unseen passages.

List of Experiments:

[1]	Load curve analysis and computation of diversity factor, coincidence factor, and load factor for different consumer categories using data sets.
[2]	Implementation of voltage drop and power loss calculations for a radial feeder using the 'K' factor method.
[3]	Modeling and evaluation of series impedance parameters (R, X) for overhead multi-conductor distribution lines.
[4]	Performance analysis and simulation of single-phase and three-phase step voltage regulators under varying load conditions.
[5]	Simulation and modeling of voltage-dependent load profiles (ZIP models) in a distribution network.
[6]	Development and execution of the Backward/Forward Sweep (BFS) load flow algorithm for a radial distribution system.
[7]	Short-circuit analysis of an unbalanced distribution network for Single Line-to-Ground (LG) and Line-to-Line (LL) faults.
[8]	Impact analysis of Distributed Generation (DG) grid integration on the feeder voltage profile and reverse power flow.

[9]	Optimal placement and sizing of shunt capacitor banks for reactive power compensation and power factor correction.
[10]	Reliability assessment of a distribution network layout through the calculation of standard indices.

Modelling and Analysis of Electrical Machines						
Course Code	<tbd>		**Examination Scheme**			
Teaching Scheme	3-0-2-1		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	4		**Laboratory**	CIE: 50	ESE: 50	--

Course Outcomes: Students will be able to:

1. Develop mathematical models of various engineering and physical systems using classical and energy approach.
2. Demonstrate linearization techniques.
3. Analyze the models for various practical systems.
4. Validate the mathematical models of practical systems using software.

Syllabus:

Modeling by first principle approach of simple Mechanical, Electrical, Thermal, Chemical systems. Modeling by energy Approach using Lagrangian and Hamiltonian. Linearization of nonlinear models, state space approach for analyzing the dynamic models. Modeling and Analysis of some typical systems such medical disease and treatment, Rocket Launcher, Resource Management etc., Numerical models using impulse response, step response. Several case studies (Mechanical, Thermal, Electric, etc.). Validation of practical system models using software.

Self-Study (SS):

1. Modeling of multi-domain physical systems with non-linear damping and friction profiles.
2. Comparative study of core loss and thermal behavior modeling in high-speed permanent magnet machines.

Textbooks:

[1]	System Dynamics, Fourth edition, Pearson Education, New Delhi, 2004.
[2]	Modern Control Engineering, Fifth edition, Prentice Hall of India, New Delhi, 2010.

Reference Books:

[1]	K. Ogata, “System Dynamics”, Pearson Prentice-Hall, 4th Edition, 2004.
[2]	M. Gopal, “Modern Control Systems Theory”, 2nd Edition, John Wiley, 1993
[3]	E.O. Doeblin, “System Modeling and Response”, John Wiley and Sons, 1980.
[4]	Desai and Lalwani, “Identification Techniques”, Tata McGraw Hill, 1977.
[5]	Goldstain, “Classical Mechanics”

Note:

[1] To measure CO1, questions may be of the type- define, identify, state, match, list, name etc.
[2] To measure CO2, questions may be of the type- explain, describe, illustrate, evaluate, give examples, compute etc.
[3] To measure CO3, questions will be based on applications of core concepts.
[4] To measure CO4, questions may be of the type- true/false with justification, theoretical fill in the blanks, theoretical problems, prove implications or corollaries of theorems, etc.
[5] To measure CO5, some questions may be based on self-study topics and comprehension of unseen passages.

List of Experiments:

[1]	Modeling of DC machines
[2]	Finite Element based analysis of DC machines
[3]	Modeling of BLDC machines
[4]	Finite Element based analysis of BLDC machines
[5]	Modeling of PMSM machines
[6]	Finite Element based analysis of PMSM machines
[7]	Modeling of SRM machines
[8]	Finite Element based analysis of SRM machines
[9]	Modeling of Synchronous machines
[10]	Finite Element based analysis of Synchronous machines

Intelligent Control						
Course Code	<tbd>		**Examination Scheme**			
Teaching Scheme	3-0-2-1		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	4		**Laboratory**	CIE: 50	ESE: 50	--

Course Outcomes: Students will be able to:

1. Understand the fundamentals of intelligent control systems and soft computing techniques.
2. Apply fuzzy logic methods for analysis and control of engineering systems.
3. Develop Artificial Neural Network (ANN)-based models and intelligent controllers.
4. Analyse and implement optimization techniques such as Genetic Algorithms and Particle Swarm Optimization.
5. Design intelligent control solutions for real-world engineering applications using simulation tools.

Unit 1: Introduction to Intelligent Control	**[8 Hrs]**
Conventional and Intelligent Control Systems, Artificial Intelligence in Control Engineering, Knowledge-Based Systems, Expert Systems, Applications of Intelligent Control.	
Unit 2: Fuzzy Logic Systems	**[8 Hrs]**
Crisp and Fuzzy Sets, Membership Functions, Fuzzy Operations and Relations, Fuzzification and Defuzzification, Fuzzy Inference Systems, Mamdani and Sugeno Models, Design of Fuzzy Controllers.	
Unit 3: Artificial Neural Networks	**[8 Hrs]**
Biological Neuron Model, Perceptron, Multilayer Perceptron, Feedforward and Recurrent Neural Networks, Learning Algorithms, Backpropagation, ANN-Based Modeling and Control	
Unit 4: Evolutionary and Optimization Techniques	**[8 Hrs]**
Genetic Algorithms, Selection, Crossover and Mutation, Particle Swarm Optimization, Ant Colony Optimization, Intelligent Optimization for Controller Tuning	
Unit 5: Advanced Intelligent Control Applications	**[8 Hrs]**
Neuro-Fuzzy Systems, Adaptive Intelligent Control, Intelligent Robotics and Automation, Intelligent Process Control, Pattern Recognition, Simulation and Case Studies.	
Self-Study (SS):	

	1. Comparative analysis and implementation of Type-2 Fuzzy Logic Systems versus traditional Type-1 systems under highly noisy industrial environments. 2. Formulation and algorithmic implementation of a basic state-space Model Predictive Control (MPC) model for reference tracking applications.
Textbooks:	
[1]	Kevin M. Passino and Stephen Yurkovich, Fuzzy Control, Addison Wesley Longman, Menlo Park, CA, 1998.
[2]	Stanislaw H. Zak, Systems & Control, Oxford University Press, 2003.
Reference Books:	
[1]	K. Passino, *Biomimicry for Optimization, Control and Automation*, Springer-Verlag, 2005.
[2]	Antsaklis P.J. and Passino K. M., *An Introduction to Intelligent and Autonomous Control*, Kluwer Academic Publishers, Norwell, MA, 1993.
[3]	Timothy J. Ross, *Fuzzy Logic with Engineering Applications*, Wiley, 1995.
[4]	Rossiter, J.A., *Predictive Control: A Practical Approach*, CRC Press, 2003.
Note:	
[1]	To measure CO1, questions may be of the type- define, identify, state, match, list, name etc.
[2]	To measure CO2, questions may be of the type- explain, describe, illustrate, evaluate, give examples, compute etc.
[3]	To measure CO3, questions will be based on applications of core concepts.
[4]	To measure CO4, questions may be of the type- true/false with justification, theoretical fill in the blanks, theoretical problems, prove implications or corollaries of theorems, etc.
[5]	To measure CO5, some questions may be based on self-study topics and comprehension of unseen passages.
List of Experiments:	
[1]	Development of a rule-based expert system layout for diagnostic fault detection in a physical system.
[2]	Implementation of standard fuzzy set operations (Union, Intersection, Complement) and crisp-to-fuzzy membership mapping.
[3]	Design and simulation of a Mamdani-type Fuzzy Logic Controller for temperature or liquid-level regulation.
[4]	Design, surface mapping, and comparative evaluation of a Sugeno-type Fuzzy Inference System against a Mamdani configuration.
[5]	Programming a single-layer perceptron to classify linearly separable logical operations and analyzing weights optimization.
[6]	Training a Multi-Layer Perceptron (MLP) using the Backpropagation algorithm for nonlinear engineering plant identification.
[7]	Implementation of an ANN-based reference tracking controller for a speed-controlled motor drive.
[8]	Application of a Genetic Algorithm (GA) to optimize the gains (K_p, K_i, K_d) of a conventional PID controller based on bio-inspired constraints.
[9]	Application of Particle Swarm Optimization (PSO) for minimizing tracking error profiles in a physical plant model.

[10]	Simulation and tuning of a basic Model Predictive Control (MPC) algorithm to achieve predictive tracking for an unconstrained single-input single-output (SISO) system.

<table>
<tr><td colspan="7" align="center">Advanced Power Electronics</td></tr>
<tr><td>Course Code</td><td colspan="2"><tbd></td><td colspan="4">Examination Scheme</td></tr>
<tr><td>Teaching Scheme</td><td>3-0-0-1</td><td></td><td>Theory</td><td>TA: 20</td><td>MSE: 30</td><td>ESE: 50</td></tr>
<tr><td>Credits</td><td>3</td><td></td><td>Laboratory</td><td>CIE: --</td><td>ESE: --</td><td>--</td></tr>
</table>

Course Outcomes: Students will be able to:

1. Describe the characteristics of switching devices and their use in practical systems.
2. Analyze the operation and modeling of non-isolated DC–DC converters.
3. Design and model isolated DC–DC converters using suitable control techniques.
4. Analyze the operation and modulation techniques of voltage source inverters and advanced inverter topologies.
5. Explain the operation and control of AC–AC power converters and protection techniques used in power electronic systems.

Unit 1: Advanced Solid-State Power Devices **[8 Hrs]**

MOSFET, GTO, IGBT, SIT, SITH, and MCT: construction, operation, switching and operating characteristics, comparison of power devices, and heat sink design.

Unit 2: DC DC Converter Operations and Modeling **[8 Hrs]**

Switch mode power converters, buck, boost, buck–boost, and Ćuk converters, operating principles, continuous and discontinuous conduction modes, and basic modeling of DC–DC converters.

Unit 3: Isolated Converters and Control Techniques **[8 Hrs]**

Fly-back and forward converters, converter design, power factor improvement techniques, voltage mode control and current mode control methods, and modeling of isolated converters.

Unit 4: Voltage Source Inverters and Advanced Inverter Techniques **[8 Hrs]**

Three-phase voltage source inverters, voltage and frequency control, harmonic reduction techniques, PWM inverters, Space Vector Modulation (SVM), multilevel inverters, current source inverters, commutation circuits, and operation and control of inverter systems.

Unit 5: AC–AC Converters and Protection Techniques **[8 Hrs]**

Three-phase AC regulators, cyclo-converters, matrix converters, output voltage control techniques, commutation methods, transient voltage suppressing techniques and applications of AC–AC converters.

Self-Study (SS):

1. Comparative evaluation of Wide-Bandgap (WBG) semiconductors, specifically Silicon Carbide (SiC) and Gallium Nitride (GaN) devices, regarding power density and switching efficiency in high-frequency applications.
2. Analysis of soft-switching paradigms, including Zero Voltage Switching (ZVS) and Zero Current Switching (ZCS) topologies, inside resonant DC-DC converters.

Textbooks:

[1]	Mohan N., Undeland T.M. and Robbins W.P., *Power Electronics: Converters, Applications and Design*, 3rd Ed., John Wiley and Sons, India, 2007.
[2]	Rashid M.H., *Power Electronics: Circuits, Devices and Applications*, 4th ed., Pearson Education, 2014.

Reference Books:	
[1]	B.K. Bose, "Power Electronics and variable frequency Drives-Technology and Applications", IEEE Press, Standard Publisher Distributer.
[2]	Christophe P. Basso, "Switch mode Power Supplies-Spice Simulations and Practical Designs", Mc Graw Hill.
[3]	Erickson Robert W. Dragan Maksimović, "Fundamentals of Power Electronics", Springer publication.
[4]	https://archive.nptel.ac.in/courses/108/107/108107128/
Note:	
[1]	To measure CO1, questions may be of the type- define, identify, state, match, list, name etc.
[2]	To measure CO2, questions may be of the type- explain, describe, illustrate, evaluate, give examples, compute etc.
[3]	To measure CO3, questions will be based on applications of core concepts.
[4]	To measure CO4, questions may be of the type- true/false with justification, theoretical fill in the blanks, theoretical problems, prove implications or corollaries of theorems, etc.
[5]	To measure CO5, some questions may be based on self-study topics and comprehension of unseen passages.