Minor Degree Courses

offered by

Department of Electrical Engineering

The department of Electrical Engineering offers the following minor degree courses for the students of undergraduate B. Tech. program of other departments in MMMUT Gorakhpur.

Minor Degree Courses offered by EED (For the B.Tech. students of another Department)

1. For holistic development of the students and as per NEP-2020 and AICTE guideline, the students may earn additional 20 credits through the minor degree courses offered by different departments of the University from Semester IV to VIII.

2. Minor degree courses are optional, but it will be helpful to align the need of industries.

2. Students can only opt for one minor degree course during his/her studies of the B. Tech. program

3. If students complete all 5 PE (professional elective) category courses offered for the minor degree (total 20 credit) from the other department for minor degree, he/shell get a B. Tech. degree in his/her own branch.

4. No extra fee for a minor degree course will be charged by the students

5. In case if a student is unable to complete all 5 PE courses as offered by the other department for minor degree at the time of completion of B. Tech. program in his/her own branch then

student will get B. Tech. degree in his/her own branch without completing the minor degree course from other Department.

6. The minor degree course may be offered by the department through MOOC, as per the guidelines in B. Tech. ordinance 3.0 for the MOOC course.

Minor Degree 1: Industrial Optimization

Category	Subject Code	Name of Subject	Credit			Total Credit
			L	T	P	
PE1	EEE-101	Linear Programming for Optimization	3	0	2	4
PE3	EEE -301	Nonlinear Optimization	3	1	0	4
PE5	EEE -501	AI & Machine Learning for Optimization	3	1	0	4
PE7	EEE -701	Application of Optimization in Industry	3	1	0	4
	EEE-705/NPTEL	Industrial Engineering and Operations Research				
PE9	EEE -901	Computational Tools for Optimization	3	1	0	4
	EEE -905/NPTEL	Artificial Intelligence in Industrial and Management Engineering				
					Total	20

Minor Degree 2: Power Electronics and Advanced Applications

Category	Subject Code	Name of Subject	Credit			Total Credit
			L	T	P	
PE1	EEE- 102	Fundamentals of Power Electronics	3	1	0	4
PE3	EEE -302	Advanced Power Converter Design	3	1	0	4
PE5	EEE -502	Control and Modulation Techniques in Power Electronics	3	1	0	4
PE7	EEE -702	Applications of Power Electronics in Emerging Technologies	3	1	0	4
PE9	EEE -902/ NPTEL	Intelligent Grid Systems and Microgrid Integration	3	1	0	4
					Total	20

Minor Degree 3: Industrial Automation and Robotics

Category	Subject Code	Name of Subject	Credit			Total Credit
			L	T	P	
PE1	EEE -103	Modelling And Simulation Techniques	3	0	2	4
PE3	EEE -303	Linear Control System	3	1	0	4
PE5	EEE -503	Introduction To Robotic Control	3	0	2	4
PE7	EEE -703	Industrial Instrumentation and Process Control	3	1	0	4
PE9	EEE -903	Numerical Methods & Optimization Techniques	3	1	0	4
	EEE-906/(NPTEL)	Industrial Automation and Control				
					Total	20

Minor Degree 4: NEXT GENERATION ELECTRIC VEHICLE

(To be offered by EED , ECED & MED)

Category	Subject Code	Name of Subject	Credit			Total Credit	Department
			L	T	P		
PE1	EEE -104	Power Electronics Systems and Grid Integration for Electric Vehicles	3	1	0	4	EED
PE3	EEC -311	Embedded System for Electric Vehicle	3	1	0	4	ECED
PE5	EME -511	Vehicle Dynamics and control	3	1	0	4	MED
PE7	EME -711	Sustainable Energy and EVs	3	1	0	4	MED
PE9	EEE -904/NPTEL	Smart Grid: Basics to Advanced Technologies	3	1	0	4	EED
						Total	20

Minor Degree 1: **Industrial Optimization**

Category	Subject Code	Name of Subject	Credit L	Credit T	Credit P	Total Credit
PE1	EEE-101	Linear Programming for Optimization	3	0	2	4
PE3	EEE -301	Nonlinear Optimization	3	1	0	4
PE5	EEE -501	AI & Machine Learning for Optimization	3	1	0	4
PE7	EEE -701	Application of Optimization in Industry	3	1	0	4
	EEE-705/NPTEL	Industrial Engineering and Operations Research				
PE9	EEE -901	Computational Tools for Optimization	3	1	0	4
	EEE -905/NPTEL	Artificial Intelligence in Industrial and Management Engineering				
					Total	20

Linear Programming for Optimization

EEE 101	**Linear Programming for Optimization**
Course Category	**:** Professional Elective (PE)
Pre-requisites	**:** NIL
Contact Hours/Week	**:** Lecture: 3, Tutorial: 0, Practical: 2
Credits	**:** 4
Course Assessment Methods	• Continuous Assessment: Tutorials, Assignments, Attendance, Quizzes, One Minor Test • Final Evaluation: One Major Theory Examination
Course Outcomes (COs)	: The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Understand fundamental concepts of Matrix algebra, matrices, determinants, and linear transformations**.**
2. Apply matrix operations, eigenvalues, eigenvectors to solve systems of linear equations and Formulating LP Problems.
3. Formulate real-world optimization problems using linear programming (LP) techniques.

4. Solve LP problems using graphical and simplex methods and its application in industry/electrical system.

Topics Covered

UNIT-I Matrix Algebra for Optimization (9hrs)

Vectors, Matrices, and Matrix Operations, Rank, Determinants, and Inverse Matrices, Eigenvalues/Eigenvectors & Positive Definite Matrices, Solving Linear Systems (Gauss Elimination, LU Decomposition)

UNIT-II Introduction to Linear Programming (LP) (9hrs)

Formulating LP Problems (Objective Functions, Constraints), Graphical Method for 2-Variable LP, Standard & Canonical Forms of LP, Duality & Economic, Interpretation of Dual Variables

UNIT-III Simplex Method & Sensitivity Analysis (9hrs)

Simplex Algorithm (Tableau, Pivoting, Optimality Conditions), Big-M & Two-Phase Simplex Methods, Sensitivity Analysis (Shadow Prices, Range of Optimality), Degeneracy & Unbounded Solutions

UNIT-IV Applications of LP in Industry/Electrical Systems (9hrs)

Production Planning & Resource Allocation, Transportation & Assignment Problems, Optimal Power Flow (DC Approximation), Network Flow Optimization (Shortest Path, Max Flow)

List of Experiments:

1. To Find the rank of a given matrix.
2. To Compute determinant and inverse of a square matrix.
3. To Find eigenvalues and eigenvectors of a matrix.
4. To Check whether a matrix is positive definite.
5. To Perform LU decomposition of a matrix.
6. To find Matrix Operations and Solving Linear Equations
7. To find Graphical Solution of a 2-Variable Linear Programming Problem
8. To Use of MATLAB () to Solve a Linear Programming Problem
9. To perform Simple Sensitivity Test – Change RHS Value and Compare
10. To find Simple Resource Allocation Problem

Books & References

11. B V. Ramana: Numerical Methods for Engineers and Scientists; (McGraw Hill)
12. J. K. Sharma: Operations Research: Theory and Applications; (Macmillan)
13. K. B. Datta : Matrix Algebra for Engineers – (PHI Learning)
14. Qingkai Kong, Timmy Siauw, Alexandre Bayen: Practical Optimization with Python (Cambridge University Press)

15. Dimitris Bertsimas and John N. Tsitsiklis: Introduction to Linear Optimization – (Athena Scientific)

Nonlinear Optimization

EEE 301	**Nonlinear Optimization**
Course Category	**:** Professional Elective (PE)
Pre-requisites	**:** NIL
Contact Hours/Week	**:** Lecture: 3, Tutorial: 1, Practical: 0
Credits	**:** 4
Course Assessment Methods	• Continuous Assessment: Tutorials, Assignments, Attendance, Quizzes, One Minor Test • Final Evaluation: One Major Theory Examination
Course Outcomes (COs)	**:** The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Understand the basics of nonlinear optimization problems and their real-world applications.
2. Formulate mixed-integer programming (MIP) models for optimization problems.
3. Apply gradient-based methods (like Newton's method) to solve nonlinear optimization problems.
4. Use branch-and-bound methods to solve mixed-integer problems.

Topics Covered

UNIT-I Integer Programming Fundamentals (9hrs)

Binary/Integer Variables in Optimization, Relaxation and Branch & Bound, Cutting Plane Methods (Gomory Cuts), Complexity Analysis (P vs. NP)

UNIT-II Mixed-Integer Linear Programming (MILP) (9hrs)

Formulating MILP Models and Problem Structures, Applications: Production Scheduling (Job Shop Problems) Facility Location Selection, Power Unit Commitment

UNIT-III Fundamentals of Nonlinear Optimization (9hrs)

Basics of LP and NLP problems, Differences between LP and NLP, Convex vs. Nonconvex Functions, Unconstrained Optimization (Gradient Descent), Optimality Conditions (KKT Conditions, Lagrange Multipliers), Penalty and Barrier Methods

UNIT-IV Applications of LP in Industry / Electrical Systems (9hrs)

Electric Vehicle Charging Station Deployment, Process Optimization in Chemical/Petroleum Industries, Robotics Path Planning, Tools for MILP: Python: PuLP, Pyomo, CVXPY

Books & References

1. K. Deb: Engineering Optimization; PHI Learning
2. S.S. Rao: Optimization Techniques; McGraw Hill
3. Hamdy A Taha: Operations Research: An Introduction; Pearson India

AI & Machine Learning for Optimization

EEE 501	**AI & Machine Learning for Optimization**
Course Category	**:** Professional Elective (PE)
Pre-requisites	**:** NIL
Contact Hours/Week	**:** Lecture: 3, Tutorial: 1, Practical: 0
Credits	**:** 4
Course Assessment Methods	• Continuous Assessment: Tutorials, Assignments, Attendance, Quizzes, One Minor Test • Final Evaluation: One Major Theory Examination
Course Outcomes (COs)	**:**The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Understand basic concepts of AI, ML, and optimization techniques.
2. Apply machine learning algorithms (like regression, classification) to solve optimization problems.
3. Implement optimization techniques (e.g., Genetic Algorithms, Particle Swarm Optimization) using Python/MATLAB.

4. Analyse real-world problems (like supply chain, scheduling) using AI/ML for optimization.

Topics Covered

UNIT-I Introduction to AI in Optimization (9hrs)

Review of Optimization Problems LP vs. NLP (convex/non-convex), AI based optimization vs. Traditional Optimization, Limitations of classical methods (LP, NLP), Supervised Learning for Optimization, Regression Techniques, Reinforcement Learning (RL) Basics, Application of AI in optimization

UNIT-II Neural Networks for Optimization (9hrs)

Neural Networks (NN), Feedforward NNs (input → hidden layers → output), AI for Electrical Systems, Practical Deep Learning, Limitations of AI

UNIT-III Reinforcement Learning (RL) Application in Industries (9hrs)

What is RL, RL with Real-World Analogies, Industrial Applications, Q-Learning for Supply Chain & Logistics, RL for traffic light optimization, Safety and Real-World Challenges

UNIT-IV Applications of AI in Smart Grids (9hrs)

AI for demand forecasting, Predictive Maintenance, Vibrational analysis of motors using ML, Low-Code AI Tools, Using AWS Lookout for Equipment, Bias in AI models

Books & References

1. K. P. Soman: AI for Engineers; PHI Learning
2. S. N. Sivanandam: Deep Learning for Beginners:Springer India
3. Anand Deshpande: Artificial Intelligence and Machine Learning:McGraw Hill India
4. P. Raja, S. P. Rajagopalan: Industry 4.0 with AI: CRC Press India

Application of Optimization in Industry

EEE 701	**Application of Optimization in Industry**
Course Category	**:** Professional Elective (PE)
Pre-requisites	**:** NIL
Contact Hours/Week	**:** Lecture: 3, Tutorial: 1, Practical: 0
Credits	**:** 4
Course Assessment Methods	• **:**Continuous Assessment: Tutorials, Assignments, Attendance, Quizzes, One Minor Test

- Final Evaluation: One Major Theory Examination

Course Outcomes (COs) **:** The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Examine optimization methods in manufacturing and production systems.
2. Interpret models for supply chain and logistics optimization.
3. Differentiate optimization techniques in energy and power systems.
4. Evaluate approaches for optimization in industrial design and process industries.

Topics Covered

UNIT 1: Optimization in Manufacturing and Production Systems (9hrs)

Production Planning and Scheduling using LP and Integer Programming, Assembly Line Balancing and Facility Layout Optimization, Resource Allocation in Job Shops and Flow Shops, Toolpath Optimization in CNC Machines

UNIT 2: Supply Chain and Logistics Optimization (9hrs)

Vehicle Routing Problem (VRP), Travelling Salesman Problem (TSP), Inventory Optimization: EOQ Models, Safety Stock, Reorder Points, Warehouse Location and Distribution Network Design, Demand Forecasting and Transportation Optimization

UNIT 3: Optimization in Energy and Power Systems (9hrs)

Unit Commitment and Economic Load Dispatch, Optimal Placement of Capacitors, PMUs, and FACTS Devices, Renewable Energy Integration and Microgrid Optimization, Demand Response and Load Forecasting

UNIT 4: Optimization in Industrial Design for Process/Control (9hrs)

Design Optimization in Automotive and Aerospace Systems, Process Parameter Optimization in Chemical and Pharma Industries, Quality Control and Six Sigma Optimization Techniques, Multi-Objective Optimization in Product Design

TEXT BOOK

1. Winston, W. L. (2004). *Operations Research: Applications and Algorithms* (4th ed.). Belmont, CA: Thomson Brooks/Cole.

2. Rardin, R. L. (1998). *Optimization in Operations Research*. Upper Saddle River, NJ: Prentice Hall.
3. Rao, S. S. (2009). *Engineering Optimization: Theory and Practice* (4th ed.). Hoboken, NJ: John Wiley & Sons.
4. Ravindran, A., & Warsing, D. P. Jr. (2012). *Supply Chain Engineering: Models and Applications*. Boca Raton, FL: CRC Press

Industrial Engineering and Operations Research

EEE 705/ NPTEL	**Industrial Engineering and Operations Research**
Course Category	**:** Professional Elective (PE)
Pre-requisites	**:** NIL
Contact Hours/Week	**:** Lecture: 3, Tutorial: 1, Practical: 0
Credits	**:** 4
Course Assessment Methods	• Continuous Assessment: Tutorials, Assignments, Attendance, Quizzes, One Minor Test • Final Evaluation: One Major Theory Examination
Course Outcomes (COs)	**:** The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Understand the fundamentals of Industrial Engineering, production systems, and work study techniques.
2. Apply quality control, forecasting, and scheduling methods in production planning.
3. Solve operations research problems using optimization techniques like LPP, transportation, and network models.
4. Analyse modern manufacturing trends including Industry 4.0/5.0, smart factories, and digital twins.

Topics Covered

Unit 1: Fundamentals of Industrial Engineering & Production Systems (9hrs)

Definition of Industrial Engineering and Operations Research**,** Production Planning and Control, Aggregate Production Planning**,** Product Design: Functional, Aesthetic & Human Factors**,** Production Methods: Job, Batch, Flow**,** Work Study: Time and Motion Study, Ergonomics**,** Introduction to Inventory Management: Lean, JIT, MRP, MRP-II, Digital SCM

Unit 2: Quality Management & Production Control Tools (9hrs)

Total Quality Management (TQM)**,** Statistical Process Control (SPC)**,** Acceptance Sampling**,** Six Sigma**,** Forecasting Techniques**,** Scheduling (Heuristic Methods)**,** Assignment Problem (Hungarian Method)

Unit 3: Industrial Trends and Economic Analysis (9hrs)

Line Balancing**,** Break-even Analysis**,** Industry 4.0 vs Industry 5.0**,** Big Data, Analytics, IoT in Manufacturing**,** Smart Factories: Digital Model, Shadow, and Twins**,** Case Study on Digital Applications in Industry

Unit 4: Operations Research and Inventory Models (9hrs)

Linear Programming: Graphical & Simplex Method**,** Dual Problem, Unit Worth of Resource**,** Transportation Problems (Balanced/Unbalanced, Degenerate)**,** Network Models: CPM & PERT**,** Queuing Theory: Poisson/Exponential Distributions, Little's Law**,** Deterministic & Probabilistic Inventory Models

TEXT BOOK

1. E.S. Buffa and R.K. Sarin, Modern Production/Operations Management, Eighth Edition, Paper back, Wiley, Singapore, 2007.
2. J. L. Riggs, Production Systems: Planning, Analysis and Control, 3rd Ed., Wiley, 1981.
3. H. A. Taha, Operations Research - An Introduction, Tenth Edition, Paper back, Pearson, India, 2019.
4. S. L. Narasimhan, D. W. McLeavey, and P. J. Billington, Production, Planning and Inventory Control, Prentice Hall, 1997.
5. A. Muhlemann, J. Oakland and K. Lockyer, Productions and Operations Management, Macmillan, 1992.
6. J. K. Sharma, Operations Research, Macmillan, 1997.
7. Jay Heizer, Barry Render, Chuck Munson and Amit Sachan, Operations Management: Sustainability and Supply Chain Management, 12th Edition, Pearson India Education Services, Noida, 2017

Computational Tools for Optimization

EEE 901	**Computational Tools for Optimization**
Course Category	**:** Professional Elective (PE)
Pre-requisites	**:** NIL
Contact Hours/Week	**:** Lecture: 3, Tutorial: 1, Practical: 0
Credits	**:** 4
Course Assessment Methods	• Continuous Assessment: Tutorials, Assignments, Attendance, Quizzes, One Minor Test • Final Evaluation: One Major Theory Examination
Course Outcomes (COs)	**:** The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Analyze various computational tools like MATLAB, Python, GAMS, and Excel Solver for solving optimization problems
2. Evaluate the performance of MATLAB optimization functions in solving constrained and unconstrained problems.
3. Examine Python-based libraries such as SciPy, Pyomo, and cvxpy for formulating and solving different optimization models.
4. Compare the efficiency of advanced optimization techniques (GA, PSO, SA) across different platforms for real-world applications.

Unit 1: Introduction to Computational Tools for Optimization
(9hrs) Overview of optimization software: MATLAB, Excel Solver, GAMS, Installation, and setup of optimization environments (MATLAB Toolboxes), Introduction to syntax and interfaces for optimization functions, defining objective functions and constraints using tools

Unit 2: Optimization using MATLAB (9hrs)
MATLAB Optimization Toolbox: fmincon, fminunc, linprog, quadprog, ga**,** solving linear and nonlinear optimization problems**,** Working with constraint functions (equality, inequality, bounds)**,** Multi-objective optimization using gamultiobj

Unit 3: Optimization using Python (9hrs)
Python libraries: SciPy.optimize, Pyomo, cvxpy, pulp, DEAP**,** Linear, nonlinear, and integer

programming using SciPy.optimize**,** Model building with Pyomo: Variables, objectives, constraints

Unit 4: Advance Evolutionary Tools for Optimization (9hrs)
Genetic Algorithm (GA), Particle Swarm Optimization (PSO), and Simulated Annealing in MATLAB**,** Comparative study: MATLAB vs Python tools for optimization**,** Optimization using MATLAB for industrial problems**.** A case study with a current optimization method.

Text Book

1. Rao, S. S. (2017). *Engineering Optimization: Theory and Practice* (4th ed.). Wiley.
2. Nocedal, J., & Wright, S. J. (2006). *Numerical Optimization* (2nd ed.). Springer.
3. Chapra, S. C., & Canale, R. P. (2015). *Numerical Methods for Engineers* (7th ed.). McGraw-Hill Education.
4. Sanderson, A. C., & Zopounidis, C. (2019). *Handbook of Research on Soft Computing and Nature-Inspired Algorithms*. IGI Global.

Artificial Intelligence in Industrial and Management Engineering

EEE 905/NPTEL	**Artificial Intelligence in Industrial and Management Engineering**
Course Category	**:** Professional Elective (PE)
Pre-requisites	**:** NIL
Contact Hours/Week	**:** Lecture: 3, Tutorial: 1, Practical: 0
Credits	**:** 4
Course Assessment Methods	• Continuous Assessment: Tutorials, Assignments, Attendance, Quizzes, One Minor Test • Final Evaluation: One Major Theory Examination
Course Outcomes (COs)	**:** The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Analyze Understand the basics, evolution, and real-world applications of Artificial Intelligence.
2. Apply knowledge representation, logic, and reasoning in AI problem-solving.
3. Analyse expert systems, NLP, and machine learning techniques.
4. Implement metaheuristic approaches for solving scheduling and layout optimization problems.

Unit 1: Introduction to AI and Knowledge Representation **(9hrs)**

Introduction to AI, Evolution and latest advancements in AI, Roles of AI in business, Knowledge representation methods, Logic and reasoning systems, Advantages & disadvantages of knowledge representation

Unit 2: Expert Systems and Search Techniques **(9hrs)**

Architecture of expert systems, Backward chaining expert systems, medical expert system case studies, Search algorithms and local search, Puzzle solving using AI, Limitations of search techniques

Unit 3: Natural Language Processing and Machine Learning **(9hrs)**

Introduction to NLP and processing stages, Speech processing and applied NLP, Basics of machine learning and inductive learning, Decision trees, Introduction to neural networks

Unit 4: Optimization using Metaheuristics **(9hrs)**

Introduction to production scheduling, Metaheuristics for scheduling, Scheduling case studies using metaheuristics, Facility layout problems, Metaheuristics for facility layout, Applied case studies on facility layout

TEXT BOOK

1. Russell, S. J., Norvig, P., Chang, M.-W., Devlin, J., Dragan, A., Forsyth, D., Goodfellow, I., Malik, J., Mansinghka, V., Pearl, J., & Wooldridge, M. J. (2022). Artificial intelligence : a modern approach (Fourth edition. Global edition). Pearson.
2. Rich, E., Knight, K., & Nair, S. B. (2009). Artificial intelligence (3rd ed). Tata McGraw-Hill

Minor Degree 2: Power Electronics and Advanced Applications

Category	**Subject Code**	**Name of Subject**	**Credit**			**Total Credit**
			L	T	P	

PE1	EEE- 102	Fundamentals of Power Electronics	3	1	0	4
PE3	EEE -302	Advanced Power Converter Design	3	1	0	4
PE5	EEE -502	Control and Modulation Techniques in Power Electronics	3	1	0	4
PE7	EEE -702	Applications of Power Electronics in Emerging Technologies	3	1	0	4
PE9	EEE -902/ NPTEL	Intelligent Grid Systems and Microgrid Integration	3	1	0	4
					Total	20

Fundamentals of Power Electronics

EEE 102	**Fundamentals of Power Electronics**
Course Category	**:** Professional Elective (PE)
Pre-requisites	**:** NIL
Contact Hours/Week	**:** Lecture: 3, Tutorial: 1, Practical: 0
Credits	**:** 4
Course Assessment Methods	• Continuous Assessment: Tutorials, Assignments, Attendance, Quizzes, One Minor Test • Final Evaluation: One Major Theory Examination
Course Outcomes (COs)	The students are expected to be able to demonstrate the following knowledge, skills, and attitudes after completing this course

1. Understand the operating principles and characteristics of power semiconductor devices.
2. Analyse controlled rectifiers for performance, THD, and power factor.
3. Design and evaluate DC-DC converters for various load conditions.
4. Examine inverter topologies and apply PWM techniques for efficient power conversion.

Topics Covered

Unit I: Introduction to Power Semiconductor Devices **(9hrs)**
Characteristics of SCR, MOSFET, IGBT, GTO. Device ratings and switching characteristics. Turn-on and turn-off methods for SCR. Gate drive and snubber circuits. Heat sinking and thermal design of devices. Comparison of device types and switching speed

Unit II: Controlled Rectifiers **(9hrs)**
Single-phase and three-phase rectifiers (half and full controlled), Performance parameters, power factor, and THD, Freewheeling effect and effect of source impedance, Controlled converter waveforms and analysis, Applications in battery chargers and DC drives

Unit III: DC-DC Converters **(9hrs)**
Buck, Boost**,** Buck-Boost, Cuk converters, Continuous and discontinuous modes of operation, Practical Design of inductors and capacitors. Efficiency analysis and performance comparison, Isolated converters (Flyback, Forward)

Unit IV: DC-AC Inverters **(9hrs)**
Single-phase and three-phase bridge inverters, PWM techniques: sinusoidal PWM, space vector PWM, Harmonic reduction methods, Current source inverters (CSI), Overmodulation and inverter protection, Applications in UPS and motor drives

Books & References

1. **M. H. Rashid**, *Power Electronics: Circuits, Devices and Applications*, Pearson Education
2. **Ned Mohan, Tore M. Undeland, William P. Robbins**, *Power Electronics: Converters, Applications, and Design*, Wiley
3. **P. S. Bimbhra**, *Power Electronics*, Khanna Publishers

Advanced Power Converter Design

EEE 302	**Advanced Power Converter Design**
Course Category	**:** Professional Elective (PE)
Pre-requisites	**:** NIL
Contact Hours/Week	**:** Lecture: 3, Tutorial: 1, Practical: 0
Credits	**:** 4
Course Assessment Methods	• Continuous Assessment: Tutorials, Assignments, Attendance, Quizzes, One Minor Test • Final Evaluation: One Major Theory Examination

Course Outcomes (COs) : The students are expected to be able to demonstrate the following knowledge, skills, and attitudes after completing this course

1. Analyze multilevel inverter topologies and their applications
2. Design resonant converters using ZVS and ZCS principles.
3. Understand the operation of modular and matrix converters used in high-voltage applications.
4. Evaluate thermal management and EMI/EMC aspects in converter design.

Topics Covered

Unit I:

Multilevel Inverter Topologies: Diode-clamped, Flying capacitor, Cascaded H-bridge • Control strategies for multilevel inverters. Applications in drives and renewable energy systems, Fault diagnosis in multilevel inverters, Neutral point balancing techniques

Unit II:

Resonant and Soft Switching Converters: Resonant converter classifications: series, parallel, LLC, Zero Voltage Switching (ZVS) and Zero Current Switching (ZCS), Design of resonant tank and control strategies, Steady-state analysis and waveform shaping, Load-independent behaviour and gain characteristics, Use in wireless and medical power supplies

Unit III:

Matrix and Modular Multilevel Converters: Introduction and Operating Principles Applications in FACTS and HVDC, Control methods and modulation schemes, Modular redundancy, and fault-tolerant design, MMC sizing and energy balancing

Unit IV:

Thermal and EMI Design Considerations: Heat sinks, cooling systems, thermal modelling • EMI/EMC compliance, Parasitic elements and PCB layout considerations, Common-mode noise and filtering techniques, Standards for electromagnetic compatibility

Books & References

1. **Bin Wu**, *High-Power Converters and AC Drives*, Wiley-IEEE Press

2. **Robert W. Erickson and Dragan Maksimović**, *Fundamentals of Power Electronics*, Springer
3. **Narayan G. Hingorani and Laszlo Gyugyi**, *Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems*, IEEE Press
4. **Adrian Ioinovici**, *Power Electronics and Energy Conversion Systems, Volume 2: Advanced and Intelligent Systems*, Wiley

Control and Modulation Techniques in Power Electronics

EEE 502	**Control and Modulation Techniques in Power Electronics**
Course Category	**:** Professional Elective (PE)
Pre-requisites	**:** NIL
Contact Hours/Week	**:** Lecture: 3, Tutorial: 1, Practical: 0
Credits	**:** 4
Course Assessment Methods	• Continuous Assessment: Tutorials, Assignments, Attendance, Quizzes, One Minor Test • Final Evaluation: One Major Theory Examination
Course Outcomes (COs)	: The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Apply classical control techniques like PI/PID to power converters
2. Implement digital control using microcontrollers and DSPs.
3. Compare various modulation strategies for converters and inverters.
4. Analyse control strategies for special converters, including PFC and resonant systems.

Topics Covered

Unit I:

Classical Control of Converters: PI, PID, PR control techniques, Voltage and current control loops, Bode plots and stability analysis, Feedforward and feedback design, Frequency response tuning, Loop compensation techniques

Unit II:

Digital Control and Implementation: ADC sampling, PWM implementation, DSP and microcontroller basics, Dead-time and delay compensation, Case studies in digital control, Interrupt and timer management, Digital signal filtering in converters

Unit III:

Modulation Strategies: PWM, SVM, sigma-delta modulation, Carrier-based and space vector approaches, Multicarrier PWM for multilevel inverters, Overmodulation and transition effects, Pulse density modulation, Adaptive modulation techniques

Unit IV:

Control of Special Converters: Control of resonant converters, Control of bidirectional and isolated converters, Power factor correction (PFC) techniques, High-frequency digital control challenges, Synchronous rectification control, Applications in UPS and chargers

Books & References

1. **Sergio Franco**, *Design with Operational Amplifiers and Analog Integrated Circuits*, McGraw-Hill.
2. **Vithayathil**, *Power Electronics: Principles and Applications*, McGraw-Hill
3. **Mohan, Undeland, Robbins**, *Power Electronics: Converters, Applications, and Design*, Wiley
4. **Bimal K. Bose**, *Modern Power Electronics and AC Drives*, Pearson Education

Applications of Power Electronics in Emerging Technologies

EEE 702	**Applications of Power Electronics in Emerging Technologies**
Course Category	**:** Professional Elective (PE)
Pre-requisites	**:** NIL
Contact Hours/Week	**:** Lecture: 3, Tutorial: 1, Practical: 0
Credits	**:** 4
Course Assessment Methods	• Continuous Assessment: Tutorials, Assignments, Attendance, Quizzes, One Minor Test • Final Evaluation: One Major Theory Examination

Course Outcomes (COs) : The students are expected to be able to demonstrate the following knowledge, skills, and attitudes after completing this course

1. Describe the role of power electronics in renewable energy systems like solar and wind.
2. Evaluate converter systems used in electric vehicles, including charging and braking.
3. Apply power electronics in industrial drives and automation.
4. Assess the integration of power electronics in smart grids and IoT-enabled systems.

Topics Covered

Unit I:

Power Electronics in Renewable Energy: Grid-connected PV inverters, Wind turbine power interfaces, MPPT algorithms and converter control, Hybrid RES systems and interface issues, Standards and protection in RES, Grid compliance and synchronization

Unit II:

Power Electronics for Electric Vehicles: DC-DC and DC-AC converters in EVs, Battery charging and regenerative braking, Drive train architecture, EV powertrain design and simulation, Bidirectional converters for EV, Battery management systems (BMS)

Unit III:

Power Electronics in Industrial Automation: VFDs and soft starters, Robotics and servo drives, Industrial power quality improvement, Harmonic filtering and compensation, Smart sensors and PLC interfacing, Industrial automation protocols, Custom power devices

Unit IV:

Power Electronics in Smart Grids and IoT: Role in smart meters, distributed generation Solid-state transformers and microgrid interfaces, IoT-enabled converters and cloud integration, Cybersecurity in smart power electronics, Real-time simulation, and hardware-in-loop

Books & References

1. **Ali Emadi**, *Advanced Electric Drive Vehicles*, CRC Press.
2. **S. N. Singh**, *Electric Power Generation, Transmission and Distribution*, PHI Learning
3. **Mukund R. Patel**, *Wind and Solar Power Systems: Design, Analysis, and Operation*, CRC Press.
4. **Frede Blaabjerg (Ed.)**, *Control of Power Electronic Converters and Systems*, Academic Press

Intelligent Grid Systems and Microgrid Integration

EEE 902/ NPTEL	**Intelligent Grid Systems and Microgrid Integration**
Course Category	**:** Professional Elective (PE)
Pre-requisites	**:** NIL
Contact Hours/Week	**:** Lecture: 3, Tutorial: 1, Practical: 0
Credits	**:** 4
Course Assessment Methods	• Continuous Assessment: Tutorials, Assignments, Attendance, Quizzes, One Minor Test • Final Evaluation: One Major Theory Examination
Course Outcomes (COs)	: The students are expected to be able to demonstrate the following knowledge, skills, and attitudes after completing this course

1. Explain the characteristics, operation, and switching behaviour of key power semiconductor devices including SCR, MOSFET, IGBT, and BJT.
2. Analyze the operation and performance of AC-DC rectifiers and understand power factor implications.
3. Evaluate the principles, design, and performance of DC-DC converters in both continuous and discontinuous modes.
4. Apply various modulation techniques (PWM, SVM) to DC-AC inverters and assess harmonic content and efficiency.
5. Explain the working and control of AC-AC converters, matrix converters, and active rectifiers.
6. Assess practical aspects such as gate drive design, snubber circuits, and thermal management in power electronics systems.
7. Illustrate the role and application of power electronics in renewable energy systems, power conditioning, and smart grid technologies.

Topics Covered

Unit I:

Power Semiconductor Devices and AC-DC Converters: Characteristics and operation of power semiconductor devices. Diodes, SCRs, BJTs, MOSFETs, and IGBTs.Review of basic semiconductor physics. Uncontrolled and controlled rectifiers (single-phase and three-phase).

Performance parameters: average voltage/current, ripple, and efficiency. Power factor considerations and effect of source impedance

Unit II:

DC-DC and DC-AC Converters: Principles and operation of DC-DC converters: Buck, Boost, Buck-Boost, and Cuk, Continuous and discontinuous conduction modes (CCM and DCM), Single-phase and three-phase inverters, PWM techniques: Sinusoidal PWM, carrier-based PWM, Harmonic reduction techniques, Introduction to current source inverters (CSI)

Unit III:

AC-AC Converters and Control of Power Converters: AC-AC converters: Voltage controllers and cycloconverters, Control strategies: Feedback and feedforward control, Classical control approaches: PI/PID for converter regulation, Introduction to space vector modulation (SVM), Specialized converters: Matrix converters and active rectifiers, Control implementation basics (sampling, modulation timing, etc.)

Unit IV:

Practical Aspects and Applications: Gate drive circuits and isolation techniques, Snubber circuit design, Heat sinking, thermal modeling, and management, Applications in renewable energy systems (solar PV, wind), Power conditioning and quality improvement techniques, Overview of power electronics in modern energy systems (smart grid, microgrids)

Books & References

1. *Fundamentals of Power Electronics* by R. W. Erickson and D. Maksimović
2. *Power Electronics: Converters, Applications, and Design* by Ned Mohan

Minor Degree 3: Industrial Automation and Robotics

Category	Subject Code	Name of Subject	Credit			Total Credit
			L	T	P	
PE1	EEE -103	Modelling And Simulation Techniques	3	0	2	4
PE3	EEE -303	Linear Control System	3	1	0	4
PE5	EEE -503	Introduction To Robotic Control	3	0	2	4

PE7	EEE -703	Industrial Instrumentation and Process Control	3	1	0	4
PE9	EEE -903	Numerical Methods & Optimization Techniques	3	1	0	4
	EEE-906/(NPTEL)	Industrial Automation and Control				
					Total	20

MODELLING AND SIMULATION TECHNIQUES

EEE-103 **MODELLING AND SIMULATION TECHNIQUES**

Course Category : Professional Elective (PE)

Pre-requisite Subject : NIL

Contact hours/week : Lecture: 3, Tutorial:0, Practical: 2

No of Credits : 4

Course Assessment Methods : Continuous assessment will be carried out through tutorials, practical work, attendance, home assignments, quizzes, one minor test, one major theory examination, and a practical examination.

Course Objectives : Study of system behavior using mathematical models and computer simulations to analyze, predict, and optimize real-world dynamic processes.

Course Outcome : The students are expected to be able to demonstrate the following knowledge, skills, and attitudes after completing this course.

1. Understand various modelling techniques and perform simulation of continuous and discrete systems.
2. Analyse dynamic responses using transfer functions and frequency domain tools like Bode plots.
3. Apply fuzzy logic concepts for intelligent control system design.
4. Explore neural network architectures and their application in modelling and decision-making tasks.

Topics Covered

Unit I: Introduction to modelling and simulation **9**

Modelling: Model classification, Mathematical, physical, and analog models, Basic of Estimation, Experimental nature of simulation, steps involved in simulation studies, Validation of simulation models, computer simulation of continuous & discrete systems.

Unit II: Dynamic Response **9**

Dynamic response of 1st order system and 2nd order system, performance measures for 2nd order system, system transfer function, transfer function of 1st and 2nd order system Block diagram algebra, signal flow diagram, state variable formulation, frequency & time domain analysis and bode plots.

Unit III: Simulation Techniques **9**

MATLAB & Simulink, Modelling and Simulation of electrical systems, Selected tool boxes for electrical systems, verification, and validation of simulation model.

Unit IV: Parameter Estimation & system Identification **9**

Introduction to System Identification and Parameter Estimation, Time Domain Functions, Open and Closed Loop Systems, SISO systems, Multivariable systems, Linear and nonlinear Models, Estimation of Model Parameters, least squares method, Recursive least squares method, Kalman filter.

List of Experiments:

1. To implement Regula Falsi method to solve algebraic equations.
2. To implement numerical integration to solve algebraic equations.
3. To implement Gauss-Siedel method for solution of simultaneous equations.
4. To implement Runge-Kutta method of order four to solve differential equations.
5. To implement Euler's method to find solution of differential equations.
6. To find optimum solution to problem parameters.
7. To find derivatives of static displacements and stresses.
8. To write Computer based algorithm and program for solution of Eigen-value problems.
9. Reduction of size of an optimization problem using reduced basis technique.
10. To find Derivatives of Eigen-values and Eigen vectors.

Textbooks:

1. Programming with MATLAB for Scientists: A Beginner's Introduction, E. Mikhailov Eugeniy, CRC Press; 1st edition, February 2, 2018.
2. MATLAB an Introduction with Applications, Rao V. Dukkipati, New Age International Publisher.
3. MATLAB for Engineers, Holly Moore, Pearson, 5th Edition, 2018
4. MATLAB: A Practical Introduction to Programming and Problem Solving, Stormy Attaway, Butterworth-Heinemann, 4th Edition, 2018
5. Essential MATLAB for Engineers and Scientists, Brian Hahn and Daniel T. Valentine, Academic Press, 6th Edition, 2016

LINEAR CONTROL SYSTEM

EEE-303		**Linear Control System**
Course Category	:	Professional Elective (PE)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial:1, Practical: 0
No of Credits	:	4
Course Assessment Methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, minor test, and one major theory examination.
Course Objectives	:	To impart foundational knowledge of control systems, including modeling, time and frequency response analysis, and design of controllers for stable and efficient system performance.
Course Outcome	:	The students are expected to be able to demonstrate the following knowledge, skills, and attitudes after completing this course.

1. Understand the principles of open-loop and closed-loop control systems and their mathematical modeling.
2. Analyze and interpret system dynamics using time-domain response techniques.
3. Evaluate system stability using Routh-Hurwitz and other algebraic methods.
4. Analyze the frequency-domain techniques such as Bode and polar plots for control system analysis.

Topics Covered

Unit I: Introduction of Control System **9**

Open loop & closed control; servomechanism; Mathematical modelling of physical systems; Transfer functions, Block diagram algebra, Signal flow graph, Mason's gain formula.

Unit II: Control System Components **9**

Constructional and working principles of AC & DC servomotors, stepper motor, and synchro, error detectors. Basic control actions: proportional (P), integral (I), derivative (D), and PID controllers.

Unit III: Time Response analysis & Stability **9**

Standard test signals, time response of first and second order systems, time response specifications, steady state errors and error constants. Stability concepts, algebraic criteria, and necessary conditions, Routh-Hurwitz criteria and limitations, root locus concept.

Unit IV: Frequency response Analysis **9**

Frequency response, correlation between time and frequency responses, polar and inverse polar plots, Bode plots. Stability in frequency domain.

Text Books

1. I. J. Nagrath and M. Gopal, "Control System Engineering", 4th Edition, New age International.
2. K. Ogata, "Modern Control Engineering", Pearson Education, 4th Indian reprint.
3. D. Roy Choudhary, "Modern Control Engineering", Prentice Hall of India.
4. Ajit K. Mandal, "Introduction to Control Engineering" New Age International, 2006.

INTRODUCTION TO ROBOTIC CONTROL

EEE-503		**Introduction To Robotic Control**
Course Category	:	Professional Elective (PE)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial:0, Practical: 2
No of Credits	:	4
Course Assessment Methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, minor test, and one major theory examination.
Course Objectives	:	To provide students with a fundamental understanding of robotic systems, including their kinematics, dynamics, sensors, and actuators, along with control techniques for effective robot operation and automation. The course aims to equip students with practical skills in modeling, simulation, and control of robotic mechanisms.
Course Outcome	:	The students are expected to be able to demonstrate the following knowledge, skills, and attitudes after completing this course.

1. Understand the basic structure, terminology, and classifications of robotic systems with emphasis on control-related features.
2. Analyze various robotic drive systems and actuators, and evaluate their suitability for specific control applications.
3. Apply knowledge of sensors and vision systems to develop feedback mechanisms for robotic control.
4. Interpret and utilize spatial transformation techniques for modeling and controlling robot motion.
5. Design and analyze simple robotic control systems using appropriate actuators, sensors, and control algorithms.
6. Demonstrate the ability to integrate drive systems, sensors, and control logic in robotic applications for industrial and automation tasks.

Topics Covered

Unit I **9**

Introduction to Robotic Systems

Basics of robotics with relevance to control systems. Robot anatomy, degrees of freedom, accuracy, and repeatability as control parameters. Overview of robot classifications and selection criteria from a control perspective. Key industrial applications with brief insights into future trends.

9

Unit II

Actuators and End-Effectors for Robotic Systems

Overview of drive systems—hydraulic, pneumatic, electric—and their control characteristics. Key features of DC/AC servo and stepper motors used in control applications. Introduction to end-effectors and basic control principles for mechanical and pneumatic grippers.

9

Unit III

Sensors and Vision

Role and types of sensors in feedback control systems. Basic sensor selection criteria. Introduction to robot vision systems (RVS), its components, and control applications. Comparison with human vision for robotic decision-making.

9

Unit IV:

Transformations and Kinematics of Robotics

Spatial descriptions and transformations essential for motion control. Homogeneous transformations and their application in trajectory planning. Introduction to Euler angles and basic transformation arithmetic in robotic control systems.

List of Experiments:

1. Model and visualize a 2-DOF or 3-DOF robot arm using Denavit-Hartenberg conventions.
2. Write MATLAB code to compute the position and orientation of the end-effector.
3. Solve for joint angles using numerical or analytical methods in MATLAB.
4. Generate and plot joint-space and Cartesian-space trajectories.
5. Implement a DC motor model in MATLAB and analyze its response.
6. Design and simulate a PID controller for motor speed and position control.
7. Create a dynamic model of a simple robot using Simulink and control it with feedback.
8. Implement stepper motor pulse sequence control and analyze motion.
9. Simulate a basic obstacle avoidance and path planning scenario.
10. Simulate noisy sensor readings and apply Kalman/ Low-pass filtering techniques.
11. Model a plant and design an adaptive controller using MATLAB functions.
12. Simulate a line-following robot using MATLAB image processing techniques.

Textbooks:

1. S. K. Saha, Introduction to Robotics 2e, TATA McGraw-Hill Education (2014).
2. John J. Craig, *Introduction to Robotics: Mechanics and Control*, 4th Edition,

Pearson (2018).
3. Mark W. Spong, Seth Hutchinson, and M. Vidyasagar, *Robot Modeling and Control*, Wiley (2005).
4. Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, and Giuseppe Oriolo, *Robotics: Modelling, Planning and Control*, Springer (2009).
5. Ken Goldberg, *Introduction to Robotics: Mechanics and Control*, Addison-Wesley (2000).
6. Frank L. Lewis, Darren M. Dawson, and Chaouki T. Abdallah, *Robot Manipulator Control: Theory and Practice*, CRC Press (2004).
7. Peter Corke, *Robotics, Vision and Control: Fundamental Algorithms in MATLAB*, Springer (2017).
8. R.K. Jain, *Fundamentals of Robotics*, Wiley Eastern Limited (1998).

INDUSTRIAL INSTRUMENTATION AND PROCESS CONTROL

EEE-703		**Industrial Instrumentation And Process Control**
Course Category	:	Professional Elective (PE)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial:1, Practical: 0
No of Credits	:	4
Course Assessment Methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, minor test, and one major theory examination.
Course Objectives	:	To provide foundational knowledge of instrumentation, transducers, sensors, and process control systems for accurate measurement, monitoring, and automation in engineering applications.
Course Outcome	:	The students are expected to demonstrate the following knowledge, skills, and attitudes after the completion of this course:

1. Understand the fundamentals and performance characteristics of instrumentation systems.
2. Select and apply appropriate transducers for measuring various non-electrical quantities.
3. Analyze and utilize different types of sensors and recording devices in engineering applications.
4. Design and evaluate process control systems using P, I, D, and PID controllers.

Topics Covered

Unit I: Fundamentals of Instrumentation Engineering **9**

Fundamentals of instrumentation engineering, Performance characteristics of instruments, Static Performance Characteristics, Dynamic Performance Characteristics & Environmental Performance Characteristics, generalized input-output configuration of instrumentation, order of systems, Response of zero, first, seconds order systems, Transfer functions.

Unit II: Transducers for Measurement of Non-Electrical Quantities **9**
Advantages of electrical transducers, definition, description, classification, characteristics, factors affecting the choice of transducers, Introduction to resistive, inductive & capacitive transducers. Transducers for measurement of displacement, velocity, acceleration, force, pressure, temperature, humidity, moisture, flow and liquid level monitoring & control. Piezo-resistive, Photo voltaic, Hall Effect, and fiber optics.

Unit III: Sensors and Recorders: **9**
Piezoelectric sensors, ultrasonic sensor, optoelectronics sensor, dissolved oxygen sensor, pollution measurement, smart sensor. Analog and digital recorders, X-Y recorder, strip chart, magnetic tape recorder, RZ & NRZ, role of microprocessor in industrial automation.

Unit IV: Process Control **9**
Principle, Elements of process control system, Process characteristics, Electronic, pneumatic & digital controllers, ON/OFF controller. Proportional (P), Integral (I), Derivative (D) and PID controllers, Introduction to PLC.

Textbooks:

1. A.K.Sawhney, “Advanced Measurements & Instrumentation”, Dhanpat Rai& Sons.
2. B.C. Nakra & K.Chaudhry, “Instrumentation, Measurement and Analysis”, Tata McGraw Hill 2nd Edition.
3. Rangan, Mani, Sharma, “Instrumentation Devices & Systems”, Tata McGraw Hill Publishing 1997.
4. W.D. Cooper and A.P. Beltried, “Electronics Instrumentation and Measurement Techniques” Prentice Hall International.
5. K Krishnaswamy and S Vijayachitra, “Industrial Instrumentation” New Age International Publisher.

NUMERICAL METHODS & OPTIMIZATION TECNIQUES

EEE-903		**NUMERICAL METHODS & OPTIMIZATION TECNIQUES**
Course Category	:	Professional Elective (PE)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial:1, Practical: 0
No of Credits	:	4

Course Assessment Methods : Continuous assessment through tutorials, attendance, home assignments, quizzes, minor test, and one major theory examination.

Course Objectives : To equip students with numerical and optimization techniques for solving engineering problems involving equations, interpolation, integration, and constrained optimization.

Course Outcome : The students are expected to be able to demonstrate the following knowledge, skills, and attitudes after completing this course.

1. To find the root of a curve using iterative methods.
2. To interpolate a curve using Gauss, Newton's interpolation formula.
3. Use the theory of optimization methods and algorithms developed for various types of optimization problems.
4. To apply the mathematical results and numerical techniques of optimization theory to Engineering problems.

Topics Covered

Unit I: Numerical Methods I **9**

Solution of algebraic and transcendental equations by Bisection, Regula- Falsi and Newton Raphson methods. Interpolation: Newton's forward and backward interpolation formulae, Lagrange's formula, and Newton's divided difference formula.

Unit II: Numerical Methods II **9**

Solution of system of linear equations by Gauss Jacobi method, Guass- Siedel method, Relaxation method and LU decomposition method, Cholesky method. Numerical differentiation, Numerical Integration: Trapezoidal Rule, Simpson's one-third and three-eight rules.

Unit III: Classical Optimization Techniques **9**

Introduction, Review of single and multi-variable optimization methods with and without constraints, Non-linear one-dimensional minimization problems, and Examples.

Unit IV: Constrained Optimization Techniques **9**

Introduction, Direct Methods, Cutting plane method, Indirect methods, convex programming problems, Exterior penalty function method, Examples, and problems. Unconstrained optimization techniques: Introduction, Descent methods, Steepest Descent methods Newton's method, Quasi-Newton's method.

Text Books

1. S.S.Rao; Engineering Optimization, New Age International.
2. E.J. Haug and J.S. Arora, Applied Optimal Design; Wiley New York.
3. P. Kandasamy, K.Thilagavathy & K.Gunavathy, Numerical Methods, S. chand Publ.

INDUSTRIAL AUTOMATION AND CONTROL

EEE-906 /NPTEL		**INDUSTRIAL AUTOMATION AND CONTROL**
Course Category	:	Professional Elective (PE)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial:1, Practical: 0
No of Credits	:	4
Course Assessment Methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, minor test, and one major theory examination.
Course Objectives	:	To equip students with foundational knowledge of industrial automation, measurement systems, PLC programming, and electrical drives for efficient control and operation in industrial environments.
Course Outcome	:	The students are expected to be able to demonstrate the following knowledge, skills, and attitudes after completing this course.

1. Understand the fundamentals of industrial automation, control systems, and their role in modern manufacturing processes.
2. Analyze various industrial measurement systems and accurately interpret sensor data for process control.
3. Develop and implement basic PLC programs for sequence and logic control applications.
4. Analyze and select appropriate electrical drives for energy-efficient industrial motor control.

Topics Covered

Unit I: Introduction **9**

Introduction to Industrial Automation and Control, Role of automation in industry, Types of production and automation systems, Industrial Sensors and Instrument Systems, Industrial Actuator Systems, Industrial Control Systems.

Unit II: Measurement Systems **9**

Measurement Systems Specifications, Temperature Measurement, Pressure and Force Measurement, Displacement and Speed Measurement, Flow Measurement, Measurement of Level, Humidity, and pH.

Unit III: Programmable Logic Control Systems **9**

Introduction to Sequence/Logic Control and Programmable Logic Controllers, The Software Environment and Programming of PLCs, Formal Modelling of Sequence Control Specifications and Structured RLL Programming, Programming of PLCs: Sequential Function Charts, . The PLC Hardware Environment.

Unit IV: Electrical Machine Drives **9**

Energy Savings with Variable Speed Drives, Step Motors: Principles, Construction and Drives, DC Motor Drives, Induction Motor Drives, BLDC Motor Drives.

References

1. https://nptel.ac.in/courses/108105063.
2. Lamb, Frank. 2013. Industrial Automation: Hands-On. 1st ed. New York: McGraw-Hill Education.
3. Rangan, Mani, Sharma, "Instrumentation Devices & Systems", Tata McGraw Hill Publishing 1997.

Minor Degree 4: **NEXT GENERATION ELECTRIC VEHICLE**

(To be offered by EED, ECED & MED)

Category	**Subject Code**	**Name of Subject**	**Credit**			**Total Credit**	**Department**
			L	T	P		
PE1	EEE -104	Power Electronics Systems and Grid Integration for Electric Vehicles	3	1	0	4	EED
PE3	EEC -311	Embedded System for Electric Vehicle	3	1	0	4	ECED
PE5	EME -511	Vehicle Dynamics and control	3	1	0	4	MED
PE7	EME -711	Sustainable Energy and EVs	3	1	0	4	MED
PE9	EEE - 904/NPTEL	Advanced Microgrid Technology	3	1	0	4	EED
					Total	20	

Power Electronics Systems and Grid Integration for Electric Vehicles

EEE-104	**Power Electronics Systems and Grid Integration for Electric Vehicles**
Course Category	Professional Elective (PE)
Pre-requisites	NIL
Contact Hours/Week	Lecture: 3, Tutorial: 1, Practical: 0
Credits	4
Course Assessment Methods	• Continuous Assessment: Tutorials, Assignments, Attendance, Quizzes, One Minor Test • Final Evaluation: One Major Theory Examination

Course Outcomes: The students are expected to be able to demonstrate the following knowledge, skills, and attitudes after completing this course:

CO1: Select and analyze semiconductor devices for EV systems.

CO2: Design and simulate converters and inverters used in EVs.

CO3: Implement and tune control algorithms in both analog and digital domains.

CO4: Integrate power electronics into EVs, renewable systems, and smart grid infrastructure.

Topics Covered

Unit I:

Power Semiconductor Devices and Converters: Characteristics and operation of SCR, MOSFET, IGBT, GTO, Turn-on/turn-off techniques, device ratings, and switching characteristics, Gate drive circuits and snubber design, Single-phase and three-phase controlled rectifiers, Buck, Boost, Buck-Boost, and Cuk DC-DC converters, Isolated topologies: Flyback and Forward converters

Unit II:

Inverters and Advanced Power Converter Topologies: Single-phase and three-phase DC-AC bridge inverters, PWM techniques: Sinusoidal PWM and Space Vector PWM, Harmonic reduction and current source inverters (CSI), Multilevel inverter topologies: Diode-clamped, Flying capacitor, CHB, Resonant converters: Series, Parallel, LLC and soft-switching (ZVS, ZCS), Matrix and Modular Multilevel Converters (MMC): Principles and applications

Unit III:

Control and Modulation in Power Converters: Classical control techniques: PI, PID, PR controllers, Voltage and current loop design with stability analysis, Digital control: PWM generation, ADC sampling, DSP/microcontroller implementation, Dead-time and delay compensation, Modulation strategies: Carrier-based PWM, SVM, multicarrier PWM, Control of resonant, bidirectional, and isolated converters; PFC techniques

Unit IV:

Applications in EVs, Renewables, and Smart Technologies: Power electronics in electric vehicle drive-trains and converter design, Battery charging systems and regenerative braking in EVs, Renewable energy interface: Grid-connected PV, wind, MPPT algorithms, VFDs, soft starters, and servo drive applications in industrial automation, Power electronics in smart grids, distributed generation, and SSTs, IoT-enabled converters, cloud-based monitoring, and EV-grid integration

Books & References

1. Muhammad H. Rashid, "Power Electronics: Circuits, Devices and Applications, 4th Edition, Pearson Education, ISBN: 978-9332542603 (Indian Edition).
2. C. Mi, M. A. Masrur and D. W. Gao, "Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives", John Wiley & Sons, 2011.
3. S. Onori, L. Serrao and G. Rizzoni, "Hybrid Electric Vehicles: Energy Management Strategies", Springer, 2015.
4. M. Ehsani, Y. Gao, S. E. Gay and A. Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design", CRC Press, 2004.
5. T. Denton, "Electric and Hybrid Vehicles", Routledge, 2016.

Embedded Systems For Automotive Applications

EEC-311	**Embedded Systems For Automotive Applications**
Course Category	**:** Professional Elective (PE)
Pre-requisites	**:** NIL
Contact Hours/Week	**:** Lecture: 3, Tutorial: 1, Practical: 0
Credits	**:** 4
Course Assessment Methods	• Continuous Assessment: Tutorials, Assignments, Attendance, Quizzes, One Minor Test • Final Evaluation: One Major Theory Examination

Course Outcomes (COs) : The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Select and analyze semiconductor devices for EV systems.

2. Design and simulate converters and inverters used in EVs.

3. Implement and tune control algorithms in both analog and digital domains.

4. Integrate power electronics into EVs, renewable systems, and smart grid infrastructure.

Topics Covered

Unit I:

Introduction to Embedded Systems in Automotive Applications: Overview of embedded systems and their role in automotive engineering; Fundamentals of microcontrollers and microprocessors used in automotive applications; Introduction to real-time operating systems (RTOS) and their importance in automotive embedded systems.

Automotive Communication Protocols: Overview of automotive communication protocols (CAN bus, LIN bus, FlexRay, etc.); Applications of embedded systems in electric vehicles and hybrid electric vehicles.

Unit II:

Embedded Systems for Vehicle Diagnostics and Maintenance: Introduction to onboard diagnostics (OBD) systems and standards (OBD-II, ISO 15765, etc.); Embedded systems for monitoring vehicle performance, emissions, and fault diagnosis; Implementation of diagnostic trouble code (DTC) retrieval and interpretation algorithms; Remote diagnostics and over-the-air (OTA) software updates in modern vehicles; Development of embedded diagnostic tools and maintenance systems for electric vehicles.

Unit III:

Automotive Infotainment and Human-Machine Interface (HMI): Introduction to automotive infotainment systems and HMI design principles, Designing and prototyping automotive infotainment systems using embedded platforms.

Unit IV:

Embedded Systems for Vehicle Safety and Driver Assistance: Overview of advanced driver assistance systems (ADAS) and their components; Embedded systems for collision avoidance, lane departure warning, and adaptive cruise control; Case studies on real-world applications of embedded systems in vehicle safety and driver assistance.

Books & References

1. Kathiresh, M., & Neelaveni, R., Automotive Embedded Systems. Springer International Publishing (2021).
2. Zurawski, R., Embedded Systems Handbook: Embedded systems design and verification. CRC press (2018).
3. Real-time embedded systems. John Wiley & Sons (2017).
4. Subhashini, N., Mohanaprasad, K., & Murugan, M., Intelligent embedded systems. D. Thalmann (Ed.). Springer (2018).
5. Nicolescu, G., & Mosterman, P. J., Model-based design for embedded systems. Crc Press. (2018).

Vehicle Dynamics And Control

EME-511	**Vehicle Dynamics And Control**
Course Category	**:** Professional Elective (PE)
Pre-requisites	**:** NIL
Contact Hours/Week	**:** Lecture: 3, Tutorial: 1, Practical: 0
Credits	**:** 4
Course Assessment Methods	• **:**Continuous Assessment: Tutorials, Assignments, Attendance, Quizzes, One Minor Test • Final Evaluation: One Major Theory Examination
Course Outcomes (COs)	: The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

Topics Covered

Unit I:

Introduction to Vehicle Dynamics: Vehicle dynamics, importance, drive assistance systems, active stability control systems, ride quality and technologies for addressing traffic congestion.

Longitudinal Dynamics: Vehicle Load Distribution – Acceleration and Braking - Brake Force Distribution, Braking Efficiency and Braking Distance - Longitudinal dynamics of a Tractor-Semi Trailer.

Unit II:

Classification Tire Mechanics – An Introduction: Mechanical Properties of Rubber - Slip, Grip and Rolling Resistance - Tire Construction and Force Development - Contact Patch and Contact Pressure Distribution.
A Simple Tire Model: Lateral Force Generation - Ply Steer and Conicity -Tire Models – Magic Formula - Classification of Tire Models and Combined Slip.

Unit III:

Lateral Dynamics: Lateral Systems Under Commercial Development, Lane departure waring, lane keeping system and yaw stability control system. Bicycle Model - Stability and Steering Conditions Understeer Gradient and State space Approach, Parameters affecting vehicle handling characteristics.

Unit IV:

Introduction to Longitudinal Control: Adaptive cruise control, Collision avoidance, Automated highway systems, Benefits of Longitudinal Automation, Anti-Lock Brake Systems, ABS functions, functioning of a stability control system.

Books & References

1. Hans. Tire and vehicle dynamics. Pacejka, Hans. Elsevier (2005).
2. Theory of ground vehicles. Wong, Jo Yung. John Wiley & Sons. (2001).
3. "The friction of pneumatic tyres". Moore, Desmond F (1975).
4. Vehicle dynamics: theory and application. Jazar, Reza N. Springer (2008).
5. Fundamentals of vehicle dynamics, Gillespie, Thomas D. (1992).
6. Vehicle dynamics and Control. Rajesh Rajamani, Springer (2012)

Sustainable Energy and EVs

EME-711	**Sustainable Energy and EVs**
Course Category	**:** Professional Elective (PE)
Pre-requisites	**:** NIL
Contact Hours/Week	**:** Lecture: 3, Tutorial: 1, Practical: 0
Credits	**:** 4

Course Assessment Methods
- **:**Continuous Assessment: Tutorials, Assignments, Attendance, Quizzes, One Minor Test
- Final Evaluation: One Major Theory Examination

Course Outcomes (COs) : The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

Topics Covered

Unit I:

Introduction
Introduction and Fundamental Concepts, Renewable and Non-renewable energy, Energy Scenario in Modern World, Fossil Fuels, Climate Change Impacts and Overview of Renewable Energy Technology, Carbon- Capture

Unit II:

Renewable energy and storage systems
Hydropower, Wind Energy, Solar Energy, Bioenergy and Biofuels, Geothermal Energy, Hydrogen energy
Introduction of Energy storage systems, Mechanical energy storage technologies, Energy storage system through Capacitor, Electrochemical Energy Storage Systems, Thermal Energy Storage Systems, Trends in Energy Storage Types and their Characteristics.

Unit III:

Electric Vehicles
Overview of Electric Vehicles in India, Vehicle Dynamics, Vehicle Subsystems: EV Power-train, Storage for EVs, EV Battery Pack design, EV Motors and Controllers, Fundamentals and Design, Vehicle Accessories, Battery Charging and Swapping

Unit IV:

Battery and thermal management system
Introduction to Electrochemical Cells, Batteries, Primary and secondary Batteries, Battery Electrode Reaction, Types of Battery: lithium-ion , lead-acid, nickel-metal hydride , solid-state , Fuel Cells, Battery Management System

Books & References
1. Energy storage, Robert A. Huggins, Springer Science & Business Media, 2010
2. The Physics of Solar Cells, Jenny A. Nelson, World Scientific Publishing Company

3. Fuel Cell Fundamentals, R. O'Hayre, S-W. Cha, W. Colella, F. B. Prinz, John Wiley and Sons, USA, 2005
4. Advanced Batteries: Materials Science Aspects, Robert Huggins, Springer; 2009.

Smart Grid: Basics to Advanced Technologies

EEE-902/ NPTEL	**Smart Grid: Basics to Advanced Technologies**
Course Category	**:** Professional Elective (PE)
Pre-requisites	**:** NIL
Contact Hours/Week	**:** Lecture: 3, Tutorial: 1, Practical: 0
Credits	**:** 4
Course Assessment Methods	• Continuous Assessment: Tutorials, Assignments, Attendance, Quizzes, One Minor Test • Final Evaluation: One Major Theory Examination
Course Outcomes (COs)	: The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Explain the structure, elements, and communication standards of smart grid systems.

2. Analyse various distributed generation and energy storage systems used in smart grids and microgrids.

3. Develop models for energy storage, DC/AC microgrids, and hybrid architectures with appropriate control strategies.

4. Evaluate protection techniques, islanding detection, phasor measurement systems, and cybersecurity in smart grid applications.

Topics Covered

Unit I:

Fundamentals of Micro Grid Systems: Introduction to Smart Grid Concepts: Need, evolution, and objectives. Architecture and communication standards of smart grid systems. Key elements and enabling technologies of smart grids. Distributed Generation (DG) resources: Solar PV, wind, small hydro, and biomass systems.

Unit II:

Energy Storage, Monitoring, and Protection: Energy Storage Technologies: Types, modeling, and battery management systems. Optimal sizing and placement of energy storage in smart grids. Wide Area Monitoring Systems (WAMS): Architecture, Phasor Measurement Units (PMU). Islanding detection techniques. Smart grid protection systems: Digital relays and coordination

Unit III:

Microgrid Operation and Control: Introduction to AC, DC, and hybrid AC-DC microgrids. Modeling of smart grid components and storage devices. Operation and control strategies for AC, DC, and hybrid microgrids. Hierarchical control techniques for microgrid management. PMU placement strategies and cyber security issues.

Unit IV:

Demonstrations, Case Studies, and Energy Management: Demand-side management and demand response. Virtual inertia and ancillary services from smart grid resources. Demonstration modules: Solar, wind, EV charging, and BMS. Harmonic mitigation and simulation of AC/DC/Hybrid microgrids. Practical smart grid design, case studies, and energy management demonstrations

Books & References

3. Ali Keyhani, Mohammad N. Marwali, Min Dai, *Integration of Green and Renewable Energy in Electric Power Systems*, Wiley, 2010.
4. James Momoh, *Smart Grid: Fundamentals of Design and Analysis*, Wiley, 2012.
5. S. Chowdhury, S. P. Chowdhury, P. Crossley, *Microgrids and Active Distribution Networks*, IET, 2009.
6. NPTEL Course: *Smart Grid: Basics to Advanced Technologies* by Prof. N. P. Padhy and Prof. P. Jena, IIT Roorkee.
7. H. Farhangi, *The Path of the Smart Grid*, IEEE Power and Energy Magazine, 2010.