# Course Structure and Syllabus

***For***

# Master of Technology (M.Tech.)
# (Automation and Control Power Systems)

**as**

**Recommended by BOS**

**(w.e.f. Academic session 2024-25)**


**Department of Electrical Engineering**
**Faculty of Engineering and Technology (FET)**
**M. J. P. Rohilkhand University, Bareilly (U. P.)**
**243006**

**May-2024**

**Preamble:**

The Department of Electrical Engineering was established in 1996 with a vision to become a front runner in nurturing young minds, to bring forth globally competent engineers-scientists. The Department, with all state-of-the-art facilities is enhancing the skills of students with futuristic knowledge and new technology that caters to Industrial and socio-economic needs. The Department offers ambience for research and innovations and keeps track with the cutting-edge technological developments emerging globally. The department has well experienced and dedicated faculty members and aims to offer the curriculum that provides broad based knowledge and simultaneously builds temper for life long process of learning and exploring.

In Rohilkhand region, FET would be the only Institute to offer the Integrated M.Tech.-PhD programme. This dual degree course will encourage and attract the researchers towards leading research areas in various arenas of Electrical Engineeringand subsequently promote the NEZ-2021 (New Education Policy) as presented by the government of India. Hence, this programme will provide bedrock to enhance the academic qualification and expertise not only to the B.Tech. students but also by the industrial personnel and teaching faculty who seek to ameliorate their knowledge.

**1. About the Program:**

It shall be a conjoined programme of minimum five years (10 semesters) to seamlessly pursue M.Tech. and Ph.D.. The first 02 years of the blended course are allotted to do M.Tech. degree and the remaining 03 years to carry out the research work. The maximum time limit to complete the program is 8 years. One year extension period may be permissible to the candidate in extreme cases with the prior approval of DRC committee.

**2. Number of seats:**

Total 30 seats are available for the course.

**3. Eligibility for Admission:**

**(i)** B.E./B.Tech. or equivalent degree of Engineering with specialisation in Electronics/ Electronics &Instrumentation/ Instrumentation and Control/ Electrical/ Electrical & Electronics/ computer science/ Information Technology and other relevant fields with minimum 60% marks for Gen/OBC (55% marks for SC/ST) or equivalent grade from a recognized university/institute.

**(ii)** For sponsored candidates, apart from qualification as mentioned in [3.(i)], a candidate should possessa minimum of 3 years experience of teaching/ research/ industry/ defence at appropriate level and should officially be sponsored by the employer for the complete tenure of the course.

**4. Mode of Admission:**

The Selection/Admission in M.Tech. course will be based on the following criteria:

- Merit list based on the Marks obtained in B.Tech. and GATE/NET score.

**5. Course Structure:**

Following is the structure of the Semester wise M.Tech. course.

**M.Tech. Semester-I**

| Sr. No. | Subjects Code | Subjects | Teaching Schedule | | | Credits |
|---|---|---|---|---|---|---|
| | | | L | T | P | |
| 1. | EEA-101T | Non-Linear Systems | 3 | 1 | 0 | 3 |
| 2. | EEA-103T | Electrical Power Distribution System | 3 | 1 | 0 | 3 |
| 3. | EEA-105T | Research Methodology and IPR | 3 | 1 | 0 | 2 |
| 4. | | Pool Elective-1 | 3 | 1 | 0 | 3 |
| 5. | | Pool Elective-2 | 3 | 1 | 0 | 3 |
| 6. | EEA-105P | Control Lab | 0 | 0 | 6 | 3 |
| 7. | EEA-107P | Power System Lab | 0 | 0 | 6 | 3 |
| **TOTAL** | | | | | | **20** |

**Total No of Hours: 32**

**Pool Elective-1**

1. Robotics and Automation (EEA-109T)
2. Mathematical Method in control (EEA-111T)
3. Digital Control (EEA-113T)

**Pool Elective-2**

1. Industrial Automation System (EEA-115T)
2. Design Aspects in Control (EEA-117T)

**M.Tech. Semester-II**

| Sr. No. | Subjects Code | Subjects | Teaching Schedule | | | Credits |
|---|---|---|---|---|---|---|
| | | | L | T | P | |
| 1. | EEA-102T | Optimal Control Theory | 3 | 1 | 0 | 3 |
| 2. | EEA-104T | Smart Grids | 3 | 1 | 0 | 3 |
| 3. | | Pool Elective-3 | 3 | 1 | 0 | 3 |
| 4. | | Pool Elective-4 | 3 | 1 | 0 | 3 |
| 5. | EEA-106P | Mini Project With Seminar | 0 | 0 | 6 | 2 |
| 6. | EEA-108P | Project Lab | 0 | 0 | 6 | 3 |
| 7. | EEA-110P | Industrial Automation Lab | 0 | 0 | 6 | 3 |
| **TOTAL** | | | | | | **20** |

**Total No of Hours: 34**

**Pool Elective-3**

1. Advance Control System (EEA-106T)
2. Advanced Robotics (EEA-108T)
3. Adaptive Learning and Control (EEA-110T)

**Pool Elective-4**

1. Model Reduction in Control (EEA-112T)
2. Robust Control (EEA-114T)
3. Networked and Multi-Agent Control Systems (EEA-116T)
4. Digital Signal Processing (EEA-118T)

**M.Tech. Semester-III**

| Sr. No. | Subjects Code | Subjects | Teaching Schedule | | | Credits |
|---|---|---|---|---|---|---|
| | | | L | T | P | |
| 1. | | Pool Elective-5 | 3 | 1 | 0 | 3 |
| 2. | | Pool Elective-6 | 3 | 1 | 0 | 3 |
| 3. | EEA-201P | Dissertation-I* | 0 | 0 | 12 | 6 |
| **TOTAL** | | | | | | **12** |

**Total No of Hours: 20**

**Pool Elective-5**

1. Artificial Intelligence and Machine learning (EEA-203T)
2. Power System Operation and Control (EEA-205T)

**Pool Elective-4**

1. Non-Conventional Energy Resources (EEA-207T)
2. Electric Vehicle and Hybrid Vehicles (EEA-209T)

**M.Tech. Semester-IV**

| Sr. No. | Subjects Code | Subjects | Teaching Schedule | | | Credits |
|---|---|---|---|---|---|---|
| | | | L | T | P | |
| 1. | EEA-202P | Dissertation -II* | 0 | 0 | 24 | 12 |
| **TOTAL** | | | | | | **12** |

**Total No of Hours: 24**

* It is desirable that candidate should publish at least 02 papers in national/international journal/ conferences.

In case of elective subjects, students can opt for relevant online MOOC/NPTEL courses recognized by AICTE, New Delhi, approved by HoD.

## M.Tech. Semester-I

**NON - LINEAR SYSTEMS** **EEA-101T** **L T P : 3 1 0**

**Unit-1:**
Introduction to nonlinear systems: Examples of phenomena, models & derivation of system equations.

**Unit-2:**
Fundamental properties: Existence & uniqueness, Dependence on initial conditions & parameters, Phase plane analysis.

**Unit-3:**
Limit cycles & oscillations. Describing function method and applications. Circle criterion.

**Unit-4:**
Lyapunov stability of autonomous systems.

**Unit-5:**
Perturbation theory & Averaging, Singular perturbation model and stability analysis.

**Unit-6:**
Basic results on Lie algebra. Controllability and Observability of nonlinear systems, Bifurcations, Chaos. Synchronization.

**Suggested Reading**

1. H. K. Khalil, "Nonlinear systems", 3rd edition, Prentice Hall, 2001.
2. J. J. E. Slotine and W. Li, "Applied nonlinear systems", Prentice Hall, 1991.
3. A. Nijemjer and A. van der schaft, "Nonlinear dynamical control systems", Springer, 1989.
4. M. Vidyasagar, "Nonlinear Systems Analysis, Society for Industrial and Applied Mathematics", 2002.
5. S. Strogatz, "Nonlinear Dynamics and Chaos", Westview Press, 2001.

## M.Tech. Semester-I

**ELECTRICAL POWER DISTRIBUTION EEA-103 L T P : 3 1 0**

**Unit-1:**
Need for Distributed generation, Renewable sources in distributed generation, Current scenario in Distributed Generation.

**Unit-2:**
Planning of DGs, Sitting and sizing of DGs optimal placement of, DG sources in distribution systems, Grid integration of DGs Different types of interfaces, Inverter based DGs and rotating machine based interfaces, Aggregation of multiple DG units.

**Unit-3:**
Technical impacts of DGs, Transmission systems Distribution systems De-regulation Impact of DGs upon protective relaying. Impact of DGs upon transient and dynamic stability of Existing, distribution systems, Steady-state and Dynamic analysis.

**Unit-4:**
Economic and control aspects of DGs Market facts., issues and challenges Limitations of DGs, Voltage control techniques, Reactive power control, Harmonics Power quality issues, Reliability of DG based systems.

**Unit-5:**
Introduction to micro-grids, Types of micro-grids: autonomous and non-autonomous grids Sizing of micro-grids, Modelling & analysis of Micro-grids with multiple DGs, Micro-grids with power electronic interfacing units.

**Unit-6:**
Transients in micro-grids, Protection of micro-grids, Case studies, Advanced topics.

**Suggested Reading**

1. H. Lee Willis, Walter G. Scott, "Distributed Power Generation-Planning and Evaluation", Marcel Decker Press.
2. M. Godoy Simoes, Felix A. Farret, "Renewable Energy Systems-Design and Analysis with Induction Generators", CRC press.
3. Stuart Borlase. "Smart Grid: Infrastructure Technology Solutions" CRC Press.

## M.Tech. Semester-I

**RESERCH METHODOLY AND IPR EEA-105T L T P : 3 1 0**

**Unit-1:**
Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.

**Unit-2:**
Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations, Plagiarism, Research ethics.

**Unit-3:**
Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee.

**Unit-4:**
Nature of Intellectual Property: Patents, Designs, Trade and Copyright.
Process of Patenting and Development: technological research, innovation, patenting, development.
International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

**Unit-5:**
Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

**Unit-6:**
New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

**References:**

1. Stuart Melville and Wayne Goddard, “Research methodology: an introduction for science & engineering students”.
2. Wayne Goddard and Stuart Melville, “Research Methodology: An Introduction”.
3. Ranjit Kumar, 2nd Edition, “Research Methodology: A Step by Step Guide for beginners”.
4. Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd, 2007.
5. Mayall , “Industrial Design”, McGraw Hill, 1992.
6. Niebel , “Product Design”, McGraw Hill, 1974.
7. Asimov , “Introduction to Design”, Prentice Hall, 1962.
8. Robert P. Merges, Peter S. Menell, Mark A. Lemley, “Intellectual Property in New Technological Age”, 2016.
9. T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008.

**M.Tech. Semester-I**
**Pool Elective-1**

**ROBOTICS AND AUTOMATION** **EEA-109** **L T P : 3 1 0**

**Unit-1:**
**Basic Concepts:** Definition and origin of robotics, different types of robotics, Various generations of robots, degrees of freedom, Asimov's laws of robotics, dynamic stabilization of robots.

**Unit-2:**
**Power Sources and Sensors:** Hydraulic, pneumatic and electric drives, Determination of HP of motor and gearing: ratio, variable speed arrangements, path determination, micro machines in robotics, Machine vision, ranging, laser, acoustic, magnetic, fibre optic and tactile sensors.

**Unit-3:**
**Manipulators, Actuators and Grippers:** Construction of manipulators, manipulator dynamics and force control. Electronic and pneumatic manipulator control circuits, end effectors.

**Unit-4:**
**Kinematics and Path Planning:** Solution of inverse kinematics problem, Multiple solution Jacobian work envelop, hill climbing techniques, Robot programming languages.

**Unit-5:**
Manufacturing and non- manufacturing applications, robot cell design, selection of robot.

**Unit-6:**
**Robot Control:** Linear methods, Non-linear methods.

**Suggested Reading:**

1. Mikell P. Weiss G.M., Nagel R.N., Odraj N.G. "Industrial Robotics", McGraw-Hill Singapore, 1996.
2. Ghosh, "Control in Robotics and Automation: Sensor Based Integration", Allied Publishers, Chennai, 1998.
3. Deb.S.R., "Robotics technology and flexible Automation", John Wiley, USA 1992.
4. Asfahl C.R., "Robots and manufacturing Automation", John Wiley, USA 1992.

**M.Tech. Semester-I**
**Pool Elective-1**

**MATHEMATICAL METHODS IN CONTROL EEA-111 L T P : 3 1 0**

**Unit-1:**
Linear Spaces- Vectors and Matrices, Transformations, Norms, Matrix Factorization.

**Unit-2:**
Eigen value, Eigen vectors and Applications, SVD and Applications, Projections and Least Square Solutions.

**Unit-3:**
Probability, Random variables, Probability distribution and density functions, Joint density and conditional distribution, Functions of random variables and random vectors.

**Unit-4:**
Characteristic functions and correlation matrices.

**Unit-5:**
Random Processes and properties, Response of Linear systems to stochastic inputs, PSD theorem.

**Suggested Reading:**

1. G. Strang, "Introduction to Linear Algebra", 4 th Edition, Wellesley-Cambridge Press, 2009.
2. Papoulis &Pillai, "Probability, random variable and stochastic processes", McGraw Hill, 2002.
3. H. Stark & J.W. Woods, "Probability and random processes with application to signal processing", Pearson Education Asia, 2002.
4. J A Gubner: "Probability and Random processes for Electrical and Computer engineers", Cambridge Univ. Press. 2006.

**M.Tech. Semester-I**
**Pool Elective-1**

**DIGITAL CONTROL** **EEA-113** **L T P : 3 1 0**

**Unit-1:**
Introduction to discrete-time systems.

**Unit-2:**
Frequency domain approach- Analysis and discretization, Time domain approach- Analysis and discretization, State space formulation for discretized systems.

**Unit-3:**
Engineering aspects of computer controlled systems.

**Unit-4:**
Sampled data systems, Control of Sampled data systems.

**Unit-5:**
Concept of differential sampling, Closed loop analysis of differentially sampled systems, Control design based on differential sampling.

**Unit-6:**
Recent applications of Digital Control.

**Suggested Reading:**
1. K. Ogata, "Discrete-time Control Systems", Ed. 2, Prentice-Hall, 1995.
2. Benjamin C. Kuo, "Digital Control Systems", Ed. 2, Oxford University Press, 1999.

**M.Tech. Semester-I**
**Pool Elective-2**

**Industrial Automation Systems** **EEA-115** **L T P : 3 1 0**

**Unit-1:**
Introduction to computer based industrial automation- Direct Digital Control (DDC), Distributed Control System (DCS) and supervisory control and data acquisition (SCADA) based architectures.

**Unit-2:**
SCADA for process industries includes understanding of RTUs, Pumping stations, Evacuation processes, Mass Flow Meters and other flow meters, Leak-flow studies of pipelines, Transport Automation.

**Unit-3:**
Programmable Logic Controller (PLC)- Block diagram of PLC, Programming languages of PLC, Basic instruction sets, Design of alarm and interlocks, Networking of PLC, Overview of safety of PLC with case studies.

**Unit-4:**
Process Safety Automation: Levels of process safety through use of PLCs, Integrating Process safety PLC and DCS, Application of international standards in process safety control.

**Unit-5:**
Distributed Control System- Local Control Unit (LCU) architecture, LCU Process Interfacing Issues, Block diagram and Overview of different LCU security design approaches, Networking of DCS.

**Unit-6:**
Introduction to communication protocols- Profibus, Field bus, HART protocols. Data gathering, Data analytics, Real-time analysis of data stream from DCS, Historian build, Integration of business inputs with process data, Leveraging RTU (as different from PLCs and DCS)

**Text Books:**

1. M.P. Groover, "Automation, Production Systems and Computer Integrated Manufacturing", 5th Edition, Pearson Education, 2009.
2. John W. Webb and Ronald A. Reis, "Programmable Logic Controllers: Principles and Applications", 5th Edition, Prentice Hall Inc., New Jersey, 2003.
3. Krishna Kant, "Computer - Based Industrial Control", 2nd Edition, Prentice Hall, New Delhi, 2011.
4. Frank D. Petruzella, "Programmable Logic Controllers", 5th Edition, McGraw- Hill, New York, 2016.

**M.Tech. Semester-I**
**Pool Elective-2**

**DESIGN ASPECT OF CONTOL** **EEA-117** **L T P : 3 1 0**

**Unit-1:**
System Modelling, review of concepts, PID Controllers- review PID Tuning- Ziegler Nichols, Cohen-Coon techniques.

**Unit-2:**
FOPDT and SOPDT systems and identification, Smith Predictor and its variations.

**Unit-3:**
State feedback review- pole placement, Eigen structure assignment, Eigen structure- time response relation, Controller gain selection, controller robustness, disturbance rejection.

**Unit-4:**
Frequency Domain Loop Shaping, Lag, Lead and Lag-lead compensators, Zero dynamics in servo control, Unstable zero dynamics- control design.

**Unit-5:**
Observer- concept and design, Case studies- Applications.

**Suggested Reading:**
1. Karl J. Astrom, Richard M. Murray, "Feedback Sytems: An Introduction for Scientists and Engineers", Princeton University Press, 2010.
2. Thomas Kailath : "Linear Systems", Prentice-Hall.

## M.Tech. Semester-I

**CONTROL LAB** **EEA-105P** **L T P : 0 0 6**

| Sr. No. | List of Experiments |
|---|---|
| **1.** | Design and simulation of Linearised models using MATLAB. |
| **2.** | Simulation and analysis of State space models for continuous time and discrete time systems using MATLAB. |
| **3.** | Design and Simulation of LTI models of Feedback Control System using MATLAB. |
| **4.** | Simulation and analysis of Digital Control System using MATLAB. |
| **5.** | Simulation and Stability analysis of control system with common non-linearities using MATLAB. |
| **6.** | Familiarization and use of MATLAB command associated with Robust Control Systems. |
| **7.** | Familiarization and use of PSIM software. |

**Note:-In addition, Institutes may include more experiments based on the expertise.**

## M.Tech. Semester-I

**POWER SYSTEM LAB** **EEA-107P** **L T P : 0 0 6**

| Sr. No. | List of Experiments |
|---|---|
| 1. | Formation of Y-BUS matrix using MATLAB/ETAP coding. |
| 2. | MATLAB/ETAP coding N-R Load flow in polar co-ordinates. |
| 3. | Load flow calculation using MATLAB/ETAP and PST package. |
| 4. | Optimal power flow using MATLAB/ETAP and PSAT. |
| 5. | Distribution load flow using MATLAB/ETAP. |
| 6. | Symmetrical and unsymmetrical fault studies using MATLAB/ETAP. |
| 7. | Small signal stability analysis using MATLAB/ETAP and PST package. |
| 8. | Transient stability analysis using MATLAB/ETAP and PST package. |
| 9. | State Estimation using MATLAB/ETAP program. |
| 10. | Power quality calculation using MATLAB/ETAP and PSCAD/EMTDC. |
| 11. | Time-domain simulation in MATLAB/ETAP and PSCAD for observing various power system scenarios like power swing, voltage instability etc. |

**Note:-In addition, Institutes may include more experiments based on the expertise**

## M.Tech. Semester-II

**OPTIMAL CONTROL THEORY** **EEA-102T** **L T P : 3 1 0**

**Unit-1:**
Optimal control problem- fundamental concepts and theorems of calculus of variations- Euler-Language equation and extremal of functional.

**Unit-2:**
Variational approach to solving optimal control problems. Hamiltonian and different boundary conditions for optimal control problem.

**Unit-3:**
Linear regulator problem - Pontryagin's minimum principle.

**Unit-4:**
Dynamic programming - Principle of optimality and its application to optimal control problem.

**Unit-5:**
Hamilton-Jacobi-Bellman equation - model reference adaptive systems (MRAS) - Design hypothesis.

**Unit-6:**
Numerical Techniques to determine optimal trajectories, Numerical Aspects of Optimization.

**Suggested Reading:**

1. M. Athans and P. L. Falb, "Optimal Control: An Introduction to the Theory and Its Applications", Dover Books on Engineering, 2006.
2. D. S. Naidu, "Optimal Control Systems", CRC Press, 2002.
3. D. Liberzon, "Calculus Of Variations and Optimal Control Theory: A Concise Introduction", Princeton University Press, Dec 2011.
4. Frank L. Lewis, Draguna Vrabie, Vassilis L. Syrmos, Optimal Control, 3rd Edition, Wiley, 2012.

## M.Tech. Semester-II

**SMART GRIDS** **EEA-104T** **L T P : 3 1 0**

**Unit-1:**
Introduction to Smart Grid, Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Concept of Robust &Self Healing Grid Present development & International policies in Smart Grid.

**Unit-2:**
Introduction to Smart Meters, Real Time Prizing, Smart Appliances,, Automatic Meter Reading(AMR), Outage Management System(OMS).

**Unit-3:**
Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid, Smart Sensors, Home & Building Automation, Smart Substations, Substation Automation, Feeder Automation.

**Unit-4:**
Geographic Information System(GIS), Intelligent Electronic Devices(IED) & their application for monitoring & protection, Smart storage like Battery, SMES, Pumped Hydro, Compressed Air Energy Storage, Wide Area Measurement System(WAMS), Phase Measurement Unit(PMU).

**Unit-5:**
Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighbourhood Area, Network (NAN), Wide Area Network (WAN), Bluetooth, ZigBee, GPS, Wi-Fi, Wi-Max based communication, Wireless Mesh Network, Basics of CLOUD Computing & Cyber Security for Smart Grid, Broadband over Power line (BPL), IP based protocols.

**Suggested Readings:**


1. Ali Keyhani, "Design of smart power grid renewable energy systems", Wiley IEEE, 2011.
2. Clark W. Gellings, "The Smart Grid: Enabling Energy Efficiency and Demand Response", CRC Press, 2009.
3. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, "Smart Grid: Technology and Applications", Wiley 2012
4. Stuart Borlase, "Smart Grid: Infrastructure, Technology and solutions " CRC Press.
5. A.G.Phadke, "Synchronized Phasor Measurement and their Applications", Springer.

**M.Tech. Semester-II**
**Pool Elective-3**

**ADVANCE CONTROL SYSTEM EEA-106T L T P : 3 1 0**

**Unit-1:**
**Math Modelling of Dynamical Systems:** Newtonian and Lagrangian approaches, Concept of dynamical state of a system, Concept of equilibrium point, linearization of non-linear model.

**Unit-2:**
**Review of Linear Algebra concepts:** Field, Vector space, linear combination, linear independence, bases of a vector space, representation of any vector on different basis, matrix representation of a linear operator, change of basis, rank, nullity, range space and null space of a Matrix Eigen value and Eigen vector of a matrix, similarity transform, Diagonalisation.

**Unit 3:**
**Modern Control Analysis:** Concept and computation of systems modes, controllability theorem and its proof, observability theorem and its proof, Controllable and observable subspaces.

**Unit-4:**
**Stability Analysis:** Stability of linear systems, stability types and their definitions for any general system, Stability of an equilibrium point, Lyapunov stability theory for LTI systems, Quadratic forms and Lyapunov functions.

**Unit-5:**
**Modern Control Design:** Converting the math model to controllable canonical form and its use for pole placement, Concept of linear observer and its design, Design of reduced order observer, Compensator design using separation principle, Poles of compensator, Open loop and close-loop systems.

**Suggested Reading:**

1. Bernard Friedland, "Control System Design: An Introduction to State-Space Methods", Dover Publications, Inc. Mineola, New York, 2012.
2. Thomas Kailath, "Linear Systems", Prentice-Hall Inc., New Jersey, 1986.
3. M. Gopal, "Modern Control System Theory", , New Age International (P) Limited, New Delhi, 2000.

**M.Tech. Semester-II**
**Pool Elective-3**

**ADVANCED ROBOTICS** **EEA-108T** **L T P : 3 1 0**

**Unit-1:**
Review of Transformations, DH Convention and Kinematics, Velocity kinematics and Jacobian.

**Unit-2:**
Robot Dynamics, Motion Planning.

**Unit-3:**
Robot control- Linear Control Techniques, Nonlinear Control Techniques.

**Unit-4:**
Holonomic and Non-holonomic Systems, Vision based Robotic Control.

**Unit-5:**
Mobile Robots- Modelling, Odometry Analysis.

**Unit-6:**
Navigation with Obstacle Avoidance, Motion Capturing Systems.

**Suggested Reading:**

1. Mark W. Spong, Seth Huchinson and M. Vidyasagar, "Robot Modeling and Control", John Wiley and Sons, Inc., 2005.
2. John J. Craig, “Introduction to Robotics: Mechanics & Control”, 3rd Edition, Prentice Hall, 2004.
3. Richard Murray, A. Lee, S. Sastry, “A Mathematical Introduction to Robotic Manipulation”, CRC Press, 1994.

**M.Tech. Semester-II**
**Pool Elective-3**

**ADAPTIVE LEARNING AND CONTROL EEA-110 T L T P : 3 1 0**

**Unit-1:**
Introduction to adaptive control, Direct and indirect adaptive control, Model reference adaptive control, Parameter convergence, Persistence of excitation.

**Unit-2:**
Review of Lyapunov stability theory.

**Unit-3:**
Adaptive back stepping, Adaptive control of nonlinear systems, Composite adaptation, Robust adaptive control.

**Unit -4:**
Neural Network-based control, Reinforcement learning-based control.

**Unit-5:**
Repetitive learning control, Predictive control, Robust adaptive control.

**Suggested Readings:**
1. H. K. Khalil, "Nonlinear Systems", 3rd edition, Prentice Hall, 2002.
2. S. Sastry and M. Bodson, "Adaptive Control", Prentice-Hall, 1989.
3. K. S. Narendra and A. M. Annaswamy, "Stable Adaptive Systems", Prentice-Hall, 1989.
4. J.J.E. Slotine, and W. Li, "Applied Nonlinear Control", Prentice-Hall, 1991.
5. P. Ioannou & B. Fidan, "Adaptive Control Tutorial", SIAM, Philadelpia, PA, 2006.

**M.Tech. Semester-II**
**Pool Elective-4**

**MODEL REDUCTION IN CONTROL EEA-112T L T P : 3 1 0**

**Unit-1:**
Introduction to Model Reduction, Source of Large Models – Circuits, EM systems, Mechanical Systems.

**Unit-2:**
Classical Model Reduction Methods- Modal reduction.

**Unit-3:**
Pade approximation and moment matching, Routh Approximants.

**Unit-4:**
Modern Methods - SVD (Grammian) based methods, Krylov based methods, SVD-Krylov based methods, MOR for Nonlinear Systems – SVD & POD Methods.

**Unit-5:**
Model Reduction in Control.

**Unit-6:**
Sliding Mode Control- Review, SMC as model reducing control, Higher Order Sliding Mode

**Suggested Reading:**
1. A. C. Antoulas, "Approximation of Large Scale Dynamical Systems", SIAM, 2005.
2. Ed. Alfio Quarteroni & Gianluigi Rozza, "Reduced Order Methods for Modelling and Computational Reduction", Springer, 2014.
3. M. Jamshidi, "Large-scale systems: modelling & control", North Holland, New York, 1983.

**M.Tech. Semester-II**
**Pool Elective-4**

**ROBUST CONTROL** **EEA-114T** **L T P : 3 1 0**

**Unit-1:**
Modelling of uncertain systems, Signals and Norms.

**Unit-2:**
Lyapunov theory for LTI systems.

**Unit-3:**
Passive systems- frequency domain Passive systems- time domain.

**Unit-4:**
Robust Stability and performance, Stabilizing controllers- Coprime factorization

**Unit-5:**
LQR, LQG problems, Ricatti equations and solutions, Ricatti equation solution through LMI.

**Unit-6:**
H-infinity control and mu-synthesis, Linear matrix inequalities for robust control.

**Suggested Reading:**
1. L. Fortuna, M. Frasca (Eds.), "Optimal and Robust Control", CRC Press, 2012.
2. K. Zhou, J. C. Doyle and K. Glover, "Robust and Optimal Control", Prentice Hall, 1996.
3. J. C. Doyle, B. A. Francis and A. R. Tannenbaum, "Feedback Control Theory", Macmillan, 1992.

**M.Tech. Semester-II**
**Pool Elective-4**

**NETWORKED AND MULTIAGENT CONTROL SYSTEMS EEA-116T L T P : 3 1 0**

**Unit-1:**
Overview of networked systems, Graph Theory Fundamentals.

**Unit-2:**
Graph-based Network Models, Network Optimization.

**Unit-3:**
Consensus Problem: cooperative control, leader-follower architecture.

**Unit-4:**
Control under Communication Constraints Formation Control, Swarming and Flocking, Collision Avoidance.

**Unit-5:**
Game Theoretic Control of Multi-Agent Systems.

**Unit-6:**
Applications: Multi-robot/vehicle coordination, Sensor Networks, Social Networks, Smart Grids, Biological Networks.

**Suggested reading:**


1. C. Godsil and G. Royle, "Algebraic Graph Theory", Springer, 2001.
2. M. Mesbahi and M. Egerstedt , "Graph Theoretic Methods in Multi-Agent Networks", Princeton University Press, 2010.
3. F. Bullo, J. Cortes, and S. Martinez, "Distributed Control of Robotic Networks", Princeton, 2009.
4. WeiRen, Randal W. Beard, "Distributed Consensus in Multi-vehicle Cooperative Control, Communications and Control Engineering Series", Springer-Verlag, London, 2008.

**M.Tech. Semester-II**
**Pool Elective-4**

**DIGITAL SIGNAL PROCESSING EEA-118T L T P : 3 1 0**

**Unit-1:**
Discrete time signals- Linear shift invariant systems- Stability and causality- Sampling of Continuous time signals Discrete time Fourier transform- Discrete Fourier series- Discrete Fourier transform- Z transform-Properties of different transforms.

**Unit-2:**
Linear convolution using DFT- Computation of DFT Design of IIR digital filters from analog filter Impulse invariance method and Bilinear transformation method.

**Unit-3:**
FIR filter design using window functions- Comparison of IIR and FIR digital filters- Basic IIR and FIR filter realization structures- Signal flow graph representations Quantization process and errors.

**Unit-4:**
Coefficient quantisation effects in IIR and FIR filters A/D conversion noise- Arithmetic round-off errors- Dynamic range scaling- Overflow oscillations and zero Input limit cycles in IIR filters, Linear Signal Models. All pole, All zero and Pole-zero models Power spectrum estimation- Spectral analysis of deterministic signals Estimation of power spectrum of stationary random signals.

**Unit-5:**
Optimum linear filters- Optimum signal estimation-Mean square error estimation - Optimum FIR and IIR Filters.

**Suggested Reading:**

1. Sanjit K Mitra, "Digital Signal Processing: A computer-based approach ",TataMc Grow-Hill Edition 1998
2. Dimitris G .Manolakis, Vinay K. Ingle and Stephen M. Kogon, "Statistical and Adaptive Signal Processing", Mc Grow Hill international editions 2000.

## M.Tech. Semester-II

**MINI PROJECT WITH SEMINAR EEA-106P L T P : 0 0 6**

In the mini project, student has to make a project and deliver a seminar in any one of the emerging technology of Electrical Engineering. Topic should be communicated to the seminar Incharge. The evaluation will be done by the committee of faculty members constituted by head of the department.

## M.Tech. Semester-II

**PROJECT LAB EEA-108P L T P : 0 0 6**

The course objectives for a project-based course are designed to provide students with hands-on experience in applying theoretical knowledge to practical, real-world problems. These objectives often include a combination of technical, analytical, and soft skills development. The common objectives for such a course:

- Utilize principles and theories learned in coursework to solve practical problems.
- Integrate interdisciplinary knowledge to address complex issues.
- Plan, initiate, and execute a project from start to finish.
- Develop and manage a project timeline, including setting milestones and deadlines.
- Allocate resources effectively and efficiently.
- Conduct thorough research to inform project decisions.
- Collect, analyze, and interpret data relevant to the project.
- Use appropriate tools and methodologies to solve problems.
- Identify, analyze, and solve problems creatively and effectively.
- Develop technical skills relevant to the project's field.
- Utilize software, tools, and technologies specific to the project's requirement.
- Present project plans, progress, and results clearly and effectively in both written and oral forms.
- Develop technical documentation and reports.

## M.Tech. Semester-II

**INDUSTRIAL AUTOMATION LAB EEA-110P L T P : 0 0 6**

| Sr. No. | List of Experiment |
|---|---|
| 1. | Study hardware and software platforms for PLC and DCS. |
| 2. | Simulate analog and digital function blocks. |
| 3. | Implementation of PLC Arithmetic Instructions. |
| 4. | Study, understand and perform experiments on timers and counters. |
| 5. | Implementation of PLC Arithmetic Instructions. |
| 6. | Tune PID controller for heat exchanger using DCS. |
| 7. | Implementation of DOL Starter. |
| 8. | Study of variable frequency drive. |

**Note:-In addition, Institutes may include more experiments based on the expertise.**

**M.Tech. Semester-III**
**Pool Elective-5**

**ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING EEA-203T L T P : 3 1 0**

**Unit-1**:
Artificial Intelligence (AI), Modelling, Simulation and AI, Growth of AI, machine learning framework, linear regression algorithms , Maximum likelihood and Bayesian Decision Theory-Bayes rule.

**Unit-2:**
Artificial Neural Network: difference between human machine and intelligence, biological neural network, artificial neuron model, Concept of Perceptron, ADALINE, Feedback in Neural Network, Neural Network Architectures.

**Unit-3:**
Convolutional Neural Network, Recurrent Neural Network, Neural Learning, Application of Neural Network in Control System and Power System.

**Unit-4:**
Introduction to Genetic Algorithms, Procedure of Genetic Algorithms, Genetic Representations, Initialization and Selection, Genetic Operators, Mutation, The Working of Genetic Algorithms, Evolutionary Programming, The Working of Evolutionary Programming, particle swarm optimization.

**Unit-5:**
Fuzzy Logic: Introduction, Foundation of Fuzzy Systems, Representing Fuzzy Elements, Basic Terms and Operations, Properties of Fuzzy Sets, Fuzzification, Defuzzification.

**Unit-6:**
Introduction to Reinforcement learning, value function, reward, state and actions. Applications of machine learning to power system and control system.

**Suggested Reading:**

1. C. Bishop, "Pattern Recognition and Machine Learning", Springer, 2006.
2. M.Gopal, Digital Control and State Variable Methods , TMH.
3. Jeeva Jose, Introduction to Machine Learning, Khanna Book Publishing Company, 2020.
4. Richard S Sutton , Andrew G Barto , Reinforcement Learning An Introduction, MIT Press.

**M.Tech. Semester-III**
**Pool Elective-5**

**POWER SYSTEM OPERATION AND CONTROL EEA-205T L T P : 3 1 0**

**Unit-1:**
**Introduction:**
Structure of power systems, Power system control center and real time computer control, SCADA system. Level decomposition in power system. Power system security. Various operational stages of power system. Power system voltage stability.

**Unit-2:**
**EconomicOperation:**
Concept and problems of unit commitment. Input-output characteristics of thermal and hydro-plants. System constraints. Optimal operation of thermal units without and with transmission losses, Penalty factor, incremental.transmission loss, transmission loss formula (without derivation). Hydrothermal scheduling long and short terms, Concept of optimal power flow.

**Unit-3:**
**Load Frequency Control:**
Concept of load frequency control, Load frequency control of single area system: Turbine speed governing system and modeling, block diagram representation of single area system, steady state analysis, dynamic response, control area concept, P-I control, load frequency control and economic dispatch control. Load frequency control of two area system: Tie line power modeling, block diagram representation of two area system, static and dynamic response

**Unit-4:**
**Automatic Voltage Control:**
Schematic diagram and block diagram representation, different types of Excitation systems & their controllers.
**Voltage and Reactive Power control:**
Concept of voltage control, methods of voltage control-control by tap changing transformer. Shunt Compensation, series compensation, phase angle compensation.

**Unit-5:**
**State Estimation:**
Detection and identification, Linear and non-linear models.
**Flexible AC Transmission Systems:**
Concept and objectives FACTs controllers, Structures & Characteristics of following FACTs Controllers. TCR, FC-TCR, TSC, SVC, STATCOM, TSSC, TCSC, SSSC, TC-PAR, UPFC.

**Text Books:**

1. D.P. Kothari & I.J. Nagrath, "Modern Power System Analysis" Tata McGraw Hill, 3rd Edition.
2. P.S.R. Murty, "Operation and control in Power Systems" B.S. Publications.
3. N.G. Hingorani &L. Gyugyi, "Understanding FACTs" Concept sand Technology of Flexible AC Transmission Systems".
4. J.Wood & B.F. Wollenburg, "Power Generation, Operation and Control" John Wiley & Sons.

**M.Tech. Semester-III**
**Pool Elective-6**

**NON-CONVENTIONAL ENERGY RESOURCES EEA-207T LTP : 310**

**Unit-1:**
**Introduction:**
Various non-conventional energy resources-importance, classification, relative merits and demerits.

**Unit-2:**
**Solar Energy:**
Solar photovoltaics: Introduction, solar radiation & its relation with photovoltaic effect. Solar cell material; silicon mono & poly crystalline, raw material other than silicon. Different types of solar cell construction and design, flat plate arrays:-optimal system sizing & protection. Photovoltaic concentration, photovoltaic systems- stand alone, PV-hybrid, grid-interactive. Stationary and tracking panels, maximum power point tracking, energy storage, converter & inverter systems & their control. Application-water pumping & power plants, cost & economics, recent developments.

**Unit-3:**
**Solarthermal:**
Thermal characteristics of solar radiation, solar collectors:-materials, types, focusing. Solar thermal power plant-layout and arrangement, solar cooling, recent Developments.

**Unit-4:**
**WindEnergy:**
Wind power and its sources, site selection criterion, wind characteristics, momentum theory, Classification of wind machines. Wind mills- different design & their control, wind generators-different types, wind farms & grid. Wind generation in India. Issues of wind integrations-intermittent supply, economics, governmental regulations & subsidies. Wind penetration & its effects, economic issues, recent developments, international scenario.

**Unit-5:**
**FuelCell:**
Basic construction & principle of operation of fuel cell, Gibbs-Helmholtz equations, thermodynamic free energy and conditions of equilibrium, classification of fuel cell, different types of fuel cell: direct type- lower medium temperature alkaline type, low temperature ion exchange membrance, direct high temperature fuel cells, Redox fuel cells, operation characteristic. Fuel cell power plants & its integration with wind and solar photo voltaic systems, smart grids.

**References;**

1. F.C. Treble, “Generating electricity from sun”, pergamon press, UK.
2. Tapan Bhattacharya, “Terrestrial solar photovoltaics”, Narosa publishing house, New Delhi, 1998.

3. G.D. Rai, “Non-conventional energy resources”, Khanna Publishers, New Delhi, 2003.
4. S.P. Sukhatme, “Solar energy principles of thermal collection and storage”, McGraw-Hill publishing company, limited, New Delhi, 1984.
5. C.J. Winter, L.C. Sizmannand Van-Hull, “Solar power plants”, Sringer-Verlog publishers, 1991.
6. N.G. Clavert, “Wind Power Principle, their application on small scale”, Calvert Technical Press edition, published 2004.
7. “Fuel Cell Handbook” (Fifth Edition) by EG&G Services, Parsons, Inc. Science Applications International Corporation.
8. I Earnest and T. Wizelius “Wind Power Plants and Projects development” PHI, 2010.

**M.Tech. Semester-III**
**Pool Elective-6**

**ELECTRIC VEHICLE AND HYBRID VEHICLES EEA-209T LTP : 310**

**Unit-1:**
History of hybrid and electric vehicles, Social and environmental importance of hybrid and electric vehicles Impact of modern drive-trains on energy supplies Basics of vehicle performance, vehicle power source characterization Transmission characteristics Mathematical models to describe vehicle performance.

**Unit-2:**
Basic concept of hybrid traction, Introduction to various hybrid drive-train topologies, Power flow control in hybrid drive-train topologies Fuel efficiency analysis.

**Unit-3:**
Introduction to electric components used in hybrid and electric Vehicles, Configuration and control of DC Motor drives, Configuration and control of Introduction Motor drives, configuration and control of Permanent Magnet Motor drives Configuration and control of Switch Reluctance, Motor drives, and drive system efficiency.

**Unit-4:**
Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics Selecting the energy storage technology, Communications, supporting subsystems.

**Unit-5:**
Introduction to energy management and their strategies used in hybrid and electric vehicle Classification of different energy management strategies Comparison of different energy management strategies Implementation issues of energy strategies. Plug-in electric vehicles, Vehicle to grid (V2G) and G2V fundamentals.

**Text Books:**
1. Mehrdad Ehsani, Yimin Gao, Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals", CRC Press, 2010.
2. James Larminie, "Electric Vehicle Technology Explained", John Wiley & Sons, 2003.
3. Iqbal Hussain, "Electric & Hybrid Vehicles – Design Fundamentals", Second Edition, CRC Press, 2011.

**Reference Books**
1. Hybrid Vehicles and the future of personal transportation, Allen Fuhs, CRC Press, 2011.
2. Vehicle Power Management: Modelling, Control and Optimization, Xi Zhang, Chris Mi, Springer, 2011.

## M.Tech. Semester-III

**DISSSERTATION-I** **EEA-201P** **L T P : 0 0 12**

The objectives of a dissertation course are designed to guide students through the process of conducting original research and writing a comprehensive dissertation. The objectives of Dissertation-I are:

- Formulate a research question or hypothesis.
- Conduct a thorough literature review to situate the research within the existing body of knowledge.
- Design a research methodology appropriate for addressing the research question.
- Critically evaluate existing research and theoretical frameworks.

## M.Tech. Semester-IV

**DISSSERTATION-I** **EEA-202P** **L T P : 0 0 24**

Students will be equipped to complete a high-quality dissertation that demonstrates their ability to conduct independent research and contribute meaningfully to their academic discipline. The objectives of Dissertation-II are:

- Analyze data using appropriate methods and tools.
- Interpret findings in the context of the research question and existing literature.
- Write a clear, coherent, and well-structured dissertation.
- Present research findings effectively in written form.
- Develop skills in academic citation and referencing.
- Understand and apply ethical principles in conducting research.
- Ensure integrity and accuracy in data collection and reporting.
- Organize research materials and data systematically.
- Present research findings in seminars, conferences, or other academic forums.
- Engage with feedback from peers, advisors, and other scholars.
- Collaborate with other researchers and contribute to the academic community.
- Publish or prepare research for publication in academic journals.