सावित्रीबाई फुले पुणे विद्यापीठ

Savitribai Phule Pune University, Pune, Maharashtra, India

Faculty of Science and Technology

Master of Engineering (2025 Pattern)

M.E. Electrical (Control Systems)

(With effect from Academic Year: 2025-26

Preface by Board of Studies

Dear Students and Teachers,

We, the members of Board of Studies Electrical Engineering, are very happy to present Master of Engineering (ME Electrical-Control Systems) syllabus effective from the Academic Year 2025-26 (2025 pattern).

This curriculum integrates a blend of core subjects, open electives, on-the-job training, internships, seminars, and research projects. This holistic approach ensures that you not only master the foundational principles of electrical engineering but also have the opportunity to explore specialized areas of interest and gain hands-on experience in real-world applications.

The revised syllabus falls in line with the objectives of Savitribai Phule Pune University, AICTE New Delhi, UGC, and various accreditation agencies by keeping an eye on technological developments, innovations, and industry requirements.

This curriculum is the result of extensive consultation with academic experts, industry professionals, and alumni to ensure relevance and excellence. It is designed not only to meet the current industry standards but also to prepare students for competitive exams, higher studies and research in the field of Electrical engineering.

As you embark on this educational journey, we encourage you to seize every opportunity to expand your horizons, collaborate with peers and faculty, and contribute to advancements in the field of electrical engineering. We would like to place on record our gratefulness to the faculty, students, industry experts and stakeholders for having helped us in the formulation of this syllabus.

Dr. Sanjay. A. Deokar
Chairman
Board of Studies (Electrical Engineering)

Members of Board of Studies	
Dr. B. E. Kushare	Dr. A. N. Sarwade
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Nomenclature

COS	Control Systems
PEO	Program Educational Objectives
WK	Knowledge and Attitude Profile
PO	Program Outcomes
PCC	Program Core Course
PEC	Program Elective Course
RM	Research Methodology
IN	Internship
OJT	On Job Training
RPR	Research Project
SEM	Seminar
PEO	Program Educational Objectives
PSO	Program Specific Outcomes
WK	Knowledge and Attitude Profile

Savitribai Phule Pune University
Master of Engineering (2025 Course)
ME-Electrical (Control Systems)
Table of Contents

Program Educational Objectives (PEO)

Program Educational Objectives (PEOs) are broad statements that describe the career and professional accomplishments that engineering graduates are expected to achieve 2 years after completing the program

PEO	PEO Focus	PEO Statements
PEO1	Core Technical Excellence	To prepare globally competent postgraduates with enhanced domain knowledge and skills attaining professional excellence and updated with modern technology to provide effective solutions for engineering and research problems.
PEO2	Breadth	To prepare the postgraduates to work as committed professionals with strong professional ethics and values, sense of responsibilities, understanding of legal, safety, health, societal, cultural and environmental issues.
PEO3	Professionalism	To prepare motivated postgraduates with research attitude, lifelong learning, investigative approach, and multidisciplinary thinking to succeed in the career in industry/academia/research
PEO4	Team Building	To prepare postgraduates with strong managerial and communication skills to work effectively as an individual as well as in teams.

Knowledge and Attitude Profile (WK)

A Knowledge and Attitude Profile (KAP), often represented as WK (Knowledge and Attitude Profile) In some contexts, is a framework or assessment tool used to evaluate an individual's knowledge and attitudes related to a specific area, topic, or domain.

WK1	A systematic, theory-based understanding of natural sciences applicable to the discipline and awareness of relevant social sciences.
WK2	Conceptually based mathematics, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline.
WK3	A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline.
WK4	Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice are as in the engineering discipline; much is at the forefront of the discipline.
WK5	Knowledge, including efficient resource use, environmental impacts, whole-life cost, re-use of resources, net zero carbon, and similar concepts, that supports engineering design and operations in a practice area.
WK6	Knowledge of engineering practice (technology) in the practice areas in the engineering discipline.
WK7	Knowledge of the role of engineering in society and identified issues in engineering practice in the discipline, such as the professional responsibility of an engineer to public safety and sustainable development.
WK8	Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues.
WK9	Ethics, inclusive behavior and conduct. Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc. with mutual understanding and respect, and of inclusive attitudes.

Program Outcomes (POs)

POs are statements that describe what students are expected to know and be able to do upon graduating from the program. These relate to the skills, knowledge, attitude and behavior that students acquire through the program. On successful completion graduating students/graduates will be able to:

PO1	Engineering knowledge	Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified inWK1 toWK4 respectively to develop to the solution of complex engineering problems
PO2	Problem analysis	Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development. (WK1toWK4)
PO3	Design/Development of Solutions	Design creative solutions for complex engineering problems and design/develop systems/ components/ processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required. (WK5)
PO4	Conduct Investigations of Complex Problems	Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (WK8)
PO5	Engineering Tool Usage	Create, select and apply appropriate techniques, resources and modern engineering &IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems. (WK2 & WK6)
PO6	The Engineer and The World	Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment. (WK1, WK5, and WK7).
PO7	Ethics	Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
PO8	Individual & Collaborative Team work	Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
PO9	Communication	Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences
PO10	Project Management and Finance	Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
PO11	Life-Long Learning	Recognize the need for and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change. (WK8)

First Year ME–Electrical Engineering (2025 Pattern)

M.E. Electrical (Control Systems)

Level 6.0															
Course Code	Course Type	Course Name	Teaching Scheme (Hrs./week)			Examination Scheme and Marks						Credits			
			Theory	Tutorial	Practical	CCE*	End-Sem	Term work	Practical	Oral	Total	Theory	Tutorial	Practical	Total
Semester I															
PCC-501-COS	Program Core Course	Optimization Techniques in Control System	4	-	-	50	50	-	-	-	100	4	-	-	4
PCC-502- COS	Program Core Course	Automation in Manufacturing	4	-	-	50	50	-	-	-	100	4	-	-	4
PCC-503- COS	Program Core Course	System Identification and Adaptive Control	4	-	-	50	50	-	-	-	100	4	-	-	4
PCC-504- COS	Program Core Course	Industrial Automation and Control	4	-	-	50	50	-	-	-	100	4	-	-	4
PCC-505- COS	Program Core Course	Laboratory Practice-I	-	-	4	-	-	25	-	25	50	-	-	2	2
PEC-521- COS	Program Elective Course	Elective-I	3	-	-	50	50	-	-	-	100	3	-	-	3
PEC-522- COS	Program Elective Course	Elective Lab-I	-	-	2	-	-	25	-	25	50	-	-	1	1
Total			**19**	**-**	**6**	**250**	**250**	**50**	**-**	**50**	**600**	**19**	**--**	**3**	**22**

CCE*: Comprehensive Continuous Evaluation (Refer ME 2025 pattern rules and regulations)

Program Elective Course (Elective –I)
PEC-521A- COS : Automation and Robotics **PEC-521B- COS** : Modeling of Dynamic System

First Year ME–Electrical Engineering (2025 Pattern)

M.E. Electrical (Control Systems)

Level 6.0															
Course Code	Course Type	Course Name	Teaching Scheme (Hrs./week)			Examination Scheme and Marks						Credits			
			Theory	Tutorial	Practical	CCE*	End-Sem	Termwork	Practical	Oral	Total	Theory	Tutorial	Practical	Total
Semester II															
PCC-551- COS	Program Core Course	Multivariable and Optimal Control System	4	-	-	50	50	-	-	-	100	4	-	-	4
PCC-552- COS	Program Core Course	Control of Power Electronics Circuits	4	-	-	50	50	-	-	-	100	4	-	-	4
PCC-553- COS	Program Core Course	Digital Signal Processing and its Applications	4	-	-	50	50	-	-	-	100	4	-	-	4
PCC-554- COS	Program Core Course	Laboratory Practice-II	-	-	4	-	-	25	-	25	50	-	-	2	2
PEC-561- COS	Program Elective Course	Elective –II	3	-	-	50	50	-	-	-	100	3	-	-	3
PEC-562- COS	Program Elective Course	Elective –III	3	-	-	50	50	-	-	-	100	3	-	-	3
SEM-581-COS	Seminar	Technical Seminar-I	-	-	4	-	-	25	-	25	50	-	-	2	2
Total			**18**	**-**	**8**	**250**	**250**	**50**	**-**	**50**	**600**	**18**	**-**	**4**	**22**

CCE*: Comprehensive Continuous Evaluation (Refer ME 2025 pattern rules and regulations)

Program Elective Course **(Elective –II)**
PEC-561A- COS: Robust Control Systems PEC-561B- COS: Large Scale System

Program Elective Course **(Elective –III)**
PEC-562A- COS: Advanced Digital Control Techniques PEC-562B- COS: Modern Control Systems

Second Year Master of Electrical Engineering (2025 Pattern)

M.E. Electrical (Control Systems)

Level 6.5																
Course Code	Course Type	Course Name	Teaching Scheme (Hrs./week)			Examination Scheme and Marks						Credits			
			Theory	Tutorial	Practical	CCE*	End-Sem	Term work	Practical	Oral	Total	Theory	Tutorial	Practical	Total
Semester III															
RM-601-COS	RM	Research Methodology	4	-	-	50	50	-	-	-	100	4	-	-	4
OJT-602- COS	OJT/ Internship	On job training/ Internship	-	-	10	-	-	100	-	-	100		-	5	5
SEM-603- COS	Seminar	Technical Seminar-II		-	8	-	-	25	-	25	50	-	-	4	4
RPR-604- COS	Research Project	Research Project stage- I	-	-	18	-	-	25	-	25	50	-	-	9	9
Total			**4**	**-**	**36**	**50**	**50**	**150**	**-**	**50**	**300**	**4**	**-**	**18**	**22**

CCE*: Comprehensive Continuous Evaluation (Refer ME 2025 pattern rules and regulations)

Level 6.5																
Course Code	Course Type	Course Name	Teaching Scheme (Hrs./week)			Examination Scheme and Marks						Credits			
			Theory	Tutorial	Practical	CCE*	End-Sem	Term work	Practical	Oral	Total	Theory	Tutorial	Practical	Total
Semester IV															
SEM-651- COS	Seminar	Technical Seminar - III	-	-	8	-	-	50	-	50	100	-	-	4	4
RPR-652- COS	Research Project	Research Project- II	-	-	36	-	-	150	-	50	200		-	18	18
Total			**-**	**-**	**44**	**-**	**-**	**200**	**-**	**100**	**300**	**-**	**-**	**22**	**22**

CCE*: Comprehensive Continuous Evaluation (Refer ME 2025 pattern rules and regulations)

सावित्रीबाई फुले पुणे विद्यापीठ

SEMESTER-I

Master of Engineering (2025 Pattern)

M.E. Electrical (Control Systems)

Savitribai Phule Pune University
Board: Electrical Engineering
ME (Control Systems) (2025 Pattern)

Course Code: PCC-501-COS		**Course Name: Optimization Techniques in Control System**
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 4 Hrs/week	04	CCE : 50 Marks
Practical : --		ESE : 50 Marks

Prerequisite: Formulation and solution of mathematical models in engineering and science applications in which one seeks to minimize or maximize an objective function, General theory and approaches for solving optimization problems, Numerical algorithms for constrained optimization problems in engineering and sciences.

Course Objectives: The course objectives are to
1.Understand and apply optimization techniques to solve industrial operations
2.Study and examine effect of different optimization techniques for same problem

Course Outcomes: Upon successful completion of this course, the students will be able to:
1.Identify the optimization of resources and apply techniques to industrial problems
2.Predict the life time of replacement items
3.Ascertain the optimal sequence to do the jobs through the machines and CPM and PERT Network models
4.Know the goal of inventory control
5.Employ the concept of Transportation and assignment problems

Course Contents

Unit No: I	**Mathematical Concepts**	**10 Hours**

Review of minima/maxima of functions, real valued function, partial derivatives gradient vector, Taylor series, Directional derivatives, direction of steepest descent, local and global extrema, unimodal function, limitations of method of differential calculus, unconstrained extrema of differentiable functions, constrained extrema, and method of Lagrange multipliers.

Unit No: II	**Optimization and Classical Techniques**	**10 Hours**

Engineering applications of optimization, optimization problem, classification of optimization problems and techniques, single variable, multivariable optimization with no constraints, equality constraints, inequality constraints unconstrained minimization, steepest descent method, conjugate gradient method, Newton's method.

Unit No: III	**Linear and Nonlinear Programming**	**10 Hours**

Linear programming problems, LP problems, involving LE constraints, simplex method, revised simplex method, duality. Non-linear programming problem: elimination methods, dichotomous search, Fibonacci method, Golden section method, interpolation methods, unconstrained optimization technique.

Unit No: IV	**Dynamic Programming**	**10 Hours**

Multistage decision process, sub optimization and principle of optimality, computational and calculus method of solution, final value and initial value problems dynamic programming in continuous time systems.

Unit No: V	**Integer and Stochastic Programming**	**10 Hours**

Integer and stochastic programming, zero-one programming, mixed integer linear programming, graphical representation, Geometry cut method, Integer nonlinear programming, and polynomial. Stochastic linear programming, nonlinear programming and dynamic programming.

Learning Resources
1. Text Books
T1: S.S. Rao, Optimization Theory and Applications", New Age International Publications. T2: Amitabh Basu, "Convexity and its application in discrete & continuous optimization", John Hopkins University, Cambridge University Press, 2025.
2. Reference Books
R1: K. V. Mital and C. Mohan, "Optimization Methods in Operations and Research Systems Analysis", New Age International Publications. R2: A. D. Belegundu and T. R. Chandrupatla, "Optimization Concepts and Applications in Engineering", Pearson Education.
3. Links to online SWAYAM/NPTEL Courses
M1: https://onlinecourses.nptel.ac.in/noc24_ee122/ **M2: https://youtu.be/BMdLYXKZZtE?si=bbZCQw76SvW-xvaF**

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3			2						2
CO2	3	3			3						1
CO3	3	2	1		2						
CO4	3	3		2	3						
CO5	3	2			2				1		2

Savitribai Phule Pune University
Board: Electrical Engineering
ME (Control Systems) (2025 Pattern)

Course Code: PCC-502-COS		**Course Name: Automation in Manufacturing**
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 4 Hrs/week	04	CCE : 50 Marks
Practical : --		ESE : 50 Marks

Prerequisite: Microprocessors, microcontrollers and its programming, PLC programming, significance of PID, basic blocks of control system and their functions

Course Objectives: The course objectives are to

1. Learn to use data acquisition using various devices and utilize it for programming to measure and control system variables
2. Make them aware of drives and system employed in industrial automation
3. Understand the concepts of cyber physical systems, trends in digital manufacturing and idea of industry 4.0

Course Outcomes: Upon successful completion of this course, the students will be able to:

1. List sensors and devices used in the industrial automation and explain their use for interfacing, sensing and measurement of variables.
2. Identify various drives and explain its operation when used in industrial automation.
3. Distinguish Hydraulic and pneumatic systems employed in industrial automation.
4. Explain characteristics of cyber physical systems
5. Describe overview of digital manufacturing with operation mode and architecture
6. Portray main idea of Industry 4.0

Course Contents

Unit No: I	**Sensors and Devices**	**10 Hours**

Data conversion devices, sensors, microsensors, transducers, signal processing devices, relays, contactors and timers. Microprocessors controllers and PLCs. Description of PID controllers.

Unit No: II	**Drives**	**10 Hours**

Drives: stepper motors, servo drives. Ball screws, linear motion bearings, cams, systems controlled by camshafts, electronic cams, indexing mechanisms, tool magazines, and transfer systems.

Unit No: III	**Hydraulic and Pneumatic Systems**	**10 Hours**

Hydraulic systems: flow, pressure and direction control valves, actuators, and supporting elements, hydraulic power packs, pumps. Pneumatics: production, distribution and conditioning of compressed air, system components and graphic representations.

Unit No: IV	**Cyber Physical Systems**	**10 Hours**

Cyber physical systems: Introduction, features, Analysis of representative domains in cyber physical systems. Dynamical systems: Continuous time models, linear systems designing controller analysis technique

Unit No: V	**Digital Manufacturing & Industry 4.0**	**10 Hours**

Introduction, Concept, research and development status of digital manufacturing, Connotation and research methods, Drivers of Industry 4.0, Changing market demand, new technological possibilities, Main idea of industry 4.0, phases of industrial development, industry 4.0: fourth industrial revolution, central features of the concept, economical potential

Learning Resources
1. Text Books
1. Boltan, W., Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, Longman, Singapore, 1999. 2. HMT Ltd. Mechatronics, Tata McGraw-Hill, New Delhi, 1988. 3. Joji, P., Pneumatic Controls, Wiley (India), 2008. 4. Waller, D. and Werner H., Hydraulics Workbook Basic Level, Festo Didactic Gmbh& Co., Germany, 2001.
2. Reference Books
1. Principles of Cyber-Physical Systems, Rajeev Alur, MIT Press London 2. Fundamentals of Digital Manufacturing Science ,Zude Zhou, Shane ShengquanXie, Dejun Chen, Springer 3. Industry 4.0: The Industrial Internet of Things, Alasdair Gilchrist, Apress 4. Big Data in Cyber-Physical Systems, Digital Manufacturing and Industry 4.0, Lidong Wanga, GuanghuiWangb, International Journal Engineering and Manufacturing, 2016, 4, 1-8

Savitribai Phule Pune University
Board: Electrical Engineering
ME (Control Systems) (2025 Pattern)

Course Code: PCC-503-COS		**Course Name: System Identification and Adaptive Control**	
Teaching Scheme		**Credits**	**Examination Scheme**
Theory	: 4 Hr/week	04	CCE : 50 Marks
Practical	: --		ESE : 50 Marks
Tutorial	: --		PR : --

Prerequisite: Signals and Systems, Modern Control Theory, Digital Control, Digital Signal Processing.

Course Objectives: The course objectives are to

1. Introduce students to the fundamentals of system identification
2. Provide the students with theoretical background for developing various linear models of dynamic systems
3. Impart an understanding of the various techniques in obtaining model estimates.
4. Provide the students with the tools necessary for analyzing the quality of experimental data andevaluating the performance of candidate model structures
5. Familiarize the students with Adaptive Control and Model Predictive Control.

Course Outcomes: Upon successful completion of this course, the students will be able to:

1. Apply the basics in system identification
2. Understand the basic properties/limitations of different identification techniques
3. Utilize various methods of estimating the system parameters iteratively.
4. Distinguish between various types of learning mechanisms
5. Make use of different methods for prediction. Demonstrate an understanding of various control techniques that require parameter identification.

Course Contents

Unit No: I	**Introduction to Identification techniques**	**10 Hours**

Basic concepts in System Identification, Principles behind different identification methods, persistently exciting input, input signals, persistent excitation, Nonparametric Methods: Transient analysis, Frequency Analysis, Correlation Analysis and Spectral Analysis , Various types of Model structure (ARMAX, Box Jenkins, OE models etc.) , Least Square Estimation, Levinson Algorithm.

Unit No: II		**10 Hours**

Recursive Estimation , Parameter estimation using prediction error method and instrumental variable method, maximum likelihood estimation, Convergence and Consistency, Model Validation, Step signal identification, Applications of identification techniques.

Unit No: III	**Kalman Filter**	**10 Hours**

Types of Kalman filters, State model for a continuous process with measurement and process noise, Kalman Filter as a state estimator, Discrete state model , Discrete-time Kalman Estimator, Prediction as filtering, Examining adaptive Kalman filters and Dual Extended Kalman Filter (DEKF).

Unit No: IV	**Learning Systems and Methods**	**10 Hours**

Various concepts related to how systems learn and adopt, Learning and pattern recognition, Parametric and non-parametric training methods, Linear discriminant function, Learning systems with and without supervision, Decision theoretic methods, Bayesian learning.

Unit No: V	**Adaptive Control**	**10 Hours**

Introduction to Adaptive Control, Parameter estimation techniques, Stability analysis, Effects of Process Variations, Various Adaptive Schemes, the MIT Rule, Determination of the Adaptation Gain, Lyapunov

Theory, Design of MRAS Using Lyapunov Theory. MPC strategy, MPC elements, Objective function, Obtaining control law, Different MPC algorithms

Learning Resources
1. Text Books
T1. Yiannis Boutalis, Dimitrios Theodoridis, Theodore Kottas and Manolis A. Christodoulou, "System Identification and Adaptive Control", Springer International Publishing AG, 2006. **T2.** Natalia Bakhtadze, "Identification, knowledge Engineering & Digital Modeling for Adaptive & Intelligent Control, MDPI AG, 2023.
2. Reference Books
R1. L.Ljung, "System Identification Theory for the user", Prentice Hall, 1999. **R2.** T. Soderstrom& P. Stoica, "System Identification", Prentice Hall **R3** M. S. Grewal, A.P. Andrews,"Kalman Filtering: Theory and Practice Using MATLAB", Second Edition, John Wiley & Sons, 2001 **R4** Mendel, J.M. and Fu, K. S. "Adaptive Learning and Pattern Recognition Systems", Academic Press, New York, 1970. **R5** Papoulis, "Probability, Random Variables and stochastic processes", 2nd Ed., McGraw Hill, 1983.
3. Links to online SWAYAM/NPTEL Courses
M1: https://archive.nptel.ac.in/cources/108/102/108102113 **M2:https://www.vlab.co.in**

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3			2						2
CO2	3	3			3						2
CO3	3	2	2		2						
CO4	3	3	2	2	2						
CO5	3	2			2				1		2

Savitribai Phule Pune University
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ME (Control Systems) (2025 Pattern)

Course Code: PCC-504-COS		**Course Name:** Industrial Automation & Control
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 4 Hr/week	04	CCE : 25
Practical : --		ESE : 50
Tutorial : --		PR : --

Prerequisite: Mathematics, PLC, Measurement, PID controllers, electrical drives.

Course Objectives:

1. Describe the structure and components of an industrial automation system
2. Explain the roles of sensors, PID controllers, PLCs, and industrial drives in automation processes
3. Demonstrate knowledge of standard industrial automation practices

Course Outcomes:

Upon successful completion of this course, the students will be able to:

1. Categorize different types of industrial automation systems and their applications
2. Identify and describe sensors used for measuring physical parameters like temperature, pressure, and force
3. Design and tune PID controllers for regulating industrial process variables
4. Develop and implement process control logic using Programmable Logic Controllers (PLCs)
5. Explain the working and selection of hydraulic and pneumatic actuators and control valves.
6. Select and justify appropriate industrial drives for specific motion control applications.

Course Contents

Unit No: I	**Introduction**	**10 Hours**

Architecture industrial automation system, development trends in industrial automation, classification of existing systems, and functionality of industrial automation system. Relay and contactor logic, AC and DC relays and their role for load control. Power and Auxiliary contactors and their usage for load control.

Unit No: II	**Automatic Control**	**10 Hours**

Introduction, P-I-D Control, manual and auto PID Control Tuning, Feed forward Control Ratio Control, Time Delay Systems and Inverse Response Systems, Special Control Structures. Temperature controller hardware architecture.

Unit No: III	**PLC**	**10 Hours**

Introduction to Sequence Control, PLC, RLL (Relay Ladder Logic), Sequence Control. Scan Cycle, Simple RLL Programs, Sequence Control. More RLL Elements, RLL Syntax, A Structured Design Approach to Sequence, PLC Hardware Environment, Introduction To CNC Machines, Contour generation and Motion Control, Allen Bradley PLC and SIEMEN PLC.

Unit No: IV	**Industrial Control**	**10 Hours**

Basics of hydraulics, Hydraulic components their functions and symbols Hydraulic actuators, Pumps and its operation, pump control, Hydraulic valves (Direction control, pressure and flow control), special valves, pressure gauges and switches, hydraulic logic circuits, Hydraulic Control System, Multiple pressure and speed operations, Industrial Hydraulic Circuit, Pneumatic systems and components Pneumatic Control Systems, compressor operation and control.

Unit No: V	**Industrial Drives**	**10 Hours**

AC Drive basics, Electrical specifications and hardware architecture .AC drive and AC motor specification

matching. AC drive power wiring and Interfacing input and output signals. Operation and control of AC motor in scalar mode. Operation and control of AC drive in vector control mode. Performance verifications of special features of AC drive. Requirement and specifications of input and output chokes, braking applications, methodology and specifications of braking resistors. Selection of power, motor and signal cables for AC drive application. Wiring and lay outing guidelines of AC drive .Energy Savings with Variable Speed Drives, DC Motor Drives, DC and BLDC Servo Drives.

Learning Resources
1. Text Books
T1.“"Electric Motor Drives: Modeling, Analysis, and Control", R. Krishnan.
2. Reference Books
R1. Lingefeng Wang, Kay Chen Tan,"Modern Industrial Automation and Software Design" John Wiley & Sons Inc. R2. K. L.S. Sharma, “Overview of Industrial Process Automation”, Elsevier R3. Kok Kiong “Drives and Control for Industrial Automation”, Springer R4. Mohamed A. El-Sharkawi,” Fundamentals of Electric Drives",
3. Links to online SWAYAM/NPTEL Courses
M1. NPTEL Course on *Industrial Automation and Control* (IIT Kharagpur): 🔗 https://onlinecourses.nptel.ac.in/noc21_me67/preview **M2.** NPTEL Course on *Automation in Manufacturing* (IIT Kanpur): 🔗 https://onlinecourses.nptel.ac.in/noc22_me123/preview **M3.** NPTEL Course on *Manufacturing Automation* (IIT Kanpur): 🔗 https://onlinecourses.nptel.ac.in/noc22_me50/preview **M4.** NPTEL Course on *Introduction to Industry 4.0 and Industrial Internet of Things* (IIT Kharagpur): 🔗 https://onlinecourses.nptel.ac.in/noc20_cs69/preview

Savitribai Phule Pune University
Board: Electrical Engineering
ME (Control Systems) (2025 Pattern)

Course Code: PCC-505- COS		**Course Name:** Laboratory Practice – I
Teaching Scheme	**Credits**	**Examination Scheme**
Practical : 4 Hrs/week	02	TW : 25 Marks
		PR : 25 Marks

A minimum of eight experiments should be performed under Lab Practice – I. Out of which minimum six experiments should be from the list below. Minimum six experiments should be based on compulsory subjects. A list of experiments that may be performed under various subjects of semester - I is given below as a guideline.

1. Optimization Techniques in Control Systems

a) Give Algorithm and flow chart for steepest descent method/conjugate gradient method with suitable example.
b) State and explain standard LP Problems (or application of simplex method for LPP) with suitable example
c) State and explain any one of the methods for unconstrained optimization (Dichotomous search, Fibonacci method and Golden section method)
d) Dynamic programming in continuous time/Discrete time system for optimal solution of control system

2. Automation in Manufacturing:

a) Motor control using dSPACE
b) Hardware realization of closed loop control of a lightly damped control system
c) Control of level/temperature/ph/flowrate using industrial PID. Performance comparison with different parameters for PID
d) PLC Programming Experiments for any two systems. Water Level Control/Control of Batch Process Reactor/ Lift Control/ Speed Control of AC Servo Motor /Automatic Star Delta Starter of Three Phase Induction Motor

3. Nonlinear Control Systems:

a) Simulate the various nonlinearities using Op. Amps.
b) Construct Phase Plane Trajectory by any method and compare it with MATLAB simulation for a nonlinear system.
c) Determination of stability of nonlinear systems using Lyapunov function.
d) Construct trajectories of Vander Pol's equation.

Savitribai Phule Pune University
Board: Electrical Engineering
ME (Control Systems) (2025 Pattern)

Course Code: PEC-521A- COS		**Course Name:** Automation and Robotics
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 3Hr/week	03	CCE : 50 Marks
Practical : --		ESE : 50 Marks

Prerequisite: Mathematics, mechanics, control system-I and microcontroller and its programming.

Course Objectives:

1. Be familiar with the automation and brief history of robot and applications.
2. Acquire the knowledge on advanced algebraic tools for the description of motion.
3. Give the student familiarity with the kinematics of robots.
4. Give knowledge about robot end effectors and their design.
5. Give knowledge about various Sensors and their applications in robots
6. Develop the ability to analyze and design the motion for articulated systems.

Course Outcomes: After the successful completion of this course, the student will be able to:

1. Explain the basic principles of Robotic technology, configurations and control of Robots Vs automation.
2. Explain the basic principles of programming and apply it for typical Pick & place, loading & unloading applications.
3. Calculate the forward kinematics and inverse kinematics of serial and parallel robots.
4. Design appropriate trajectory planning as well as path planning for a robotic system and its motion control.
5. Design and implement robots which can meet dynamic constraints, latest algorithms & analytical approaches.
6. Choose the appropriate Sensor and Machine vision system for a given application.

Course Contents

Unit No: I	**Automation**	**08 Hours**

Basic concept of automation; types of automation: fixed, flexible and programmable and their comparative study; Modelling and simulation for plant automation; Introduction to NC and CNC machines; Arm and hand prostheses; exoskeletons; locomotive mechanism.

Unit No: II	**Fundamentals of Robot Technology**	**08 Hours**

Robotics: A brief history; definition; laws of Robotics; Concept of Work cell, Basic components of robot, Specifications of robot: degrees of freedom (DOF), accuracy, repeatability, spatial resolution, compliance, loads carrying capacity, speed of response, work volume, work envelope, reach etc.; links & Joints; end effectors; Robot classification. Factors related to use Robot Performance, Basic Robot Configurations and their Relative Merits and Demerits, the Wrist & Gripper Subassemblies.

Unit No: III	**Kinematics of Robot Manipulator**	**08 Hours**

Introduction, General Mathematical Preliminaries on Vectors & Matrices, Direct Kinematics problem, Geometry Based Direct kinematics problem, Co-ordinate and vector transformation using matrices, Rotation matrix, Inverse Transformations, Problems on composite Rotation matrix, Homogenous Transformations, Robotic Manipulator Joint Co-Ordinate System, Euler Angle & Euler Transformations, Roll Pitch-Yaw(RPY) Transformation, DH Representation & Displacement Matrices for Standard Configurations, Jacobian Transformation in Robotic Manipulation.

Unit No: IV	**Trajectory Planning and Robot Control**	**08 Hours**

Introduction; Trajectory Interpolators; Basic Structure of Trajectory Interpolators; Cubic Joint Trajectories; General Design Consideration on Trajectories:4-3-4 & 3-5-3 Trajectories; Via point trajectories. Control of

Robot manipulator: joint position controls (JPC), resolved motion position controls (RMPC) and resolved motion rate control (RMRC).		
Unit No: V	**Dynamics of Robotic Manipulators, Robot Sensing & Vision**	**08 Hours**
Introduction, Preliminary, Generalized Robotic Coordinates, Jacobian for a Two link Manipulator, Euler Equations, The Lagrangian Equations of motion; Application of Lagrange–Euler (LE); Dynamic Modelling of Robotic Manipulators, Various Sensors and their Classification; Use of Sensors and Sensor based System in Robotics; Machine Vision System, Description, Sensing, Digitizing, Image Processing and Analysis		

Learning Resources

1. Textbooks

T1. Richard D. Klafter, Thomas A. Chemielewski, Michael Neign "Robotic Engineering – An Integral Approach", Prentice Hall of India Pvt. Ltd., 2002.

2. Reference Books

R1. Robert J. Schilling, "Fundamentals of Robotics: Analysis and Control", Prentice Hall of India, New Delhi.

R2. John J. Craig, "Introduction to Robotics: Mechanics and Control", Pearson Education.

R3. K. S. Fu., R. C. Gonzalez, C. S. G. Lee, "Robotics: Control Sensing, Vision and Intelligence", International Edition, McGraw Hill Book Co.

R4. R. K. Mittal, I. J. Nagrath, "Robotics and Control", Tata McGraw Hill Publishing Company Ltd., New Delhi.

3. Links to online SWAYAM/NPTEL Courses

M1: https://archive.nptel.ac.in/cources/108/102/108102113

M2:https://www.vlab.co.in

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3			2						2
CO2	3	3			3						2
CO3	3	2	2		2						
CO4	3	3	2	2	2						
CO5	3	2			2				1		2

Savitribai Phule Pune University
Board: Electrical Engineering
ME (Control Systems) (2025 Pattern)

Course Code: PEC-521B- COS		**Course Name:** Modeling of Dynamic Systems
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 3 Hrs/week	03	CCE : 50
Practical : --		ESE : 50

Prerequisite: Laplace and z-transform, Differential equations, Control systems, Electrical network, Signal processing, Thermal and fluid systems

Course Objectives: The course objectives are to

1. Learn the concept of dynamic systems
2. Understand modeling of physical systems for control system studies.
3. Develop model of mechanical, electrical, fluid systems
4. Learn various methods of developing model of dynamic systems

Course Outcomes: Upon successful completion of this course, the students will be able to:

1. Explain meaning of dynamic systems and classify various dynamic systems
2. Develop a mathematical model from electrical and mechanical systems
3. Use thermal and fluid properties to develop mathematical model for control system analysis
4. Use of frequency response techniques and simulation software to develop model of physical system.
5. Employ statistical tools to obtain model from system input & output data. Use of distributed parameter model

Course Contents

Unit No: I	**Introduction**	**08 Hours**

Introduction to Dynamic systems, Examples of dynamic systems, Classification of system inputs, classification of system models, System modeling and simulation

Unit No: II	**Modeling of Mechanical and Electrical Systems:**	**07 Hours**

Translational systems: Springs, Dampers, Mass, Rotational Systems; D'Alembert's Principle,
Lagranges's Equation, Three dimensional motions, Electric Systems: Basic Elements, Passive Circuit Analysis, Active circuit analysis: The operational amplifier Mechanics.

Unit No: III	**Modeling of Fluid Systems**	**08 Hours**

Properties of fluids, density, equation of state, liquids and gases, viscosity, propagation of speed, Thermal properties, Reynolds Number Effects. Derivation of passive components, resistance, inductance and capacitance. Thermal System: Basic Effects, conduction, convection and Radiation, Circuit analysis of static thermal system: Signal and Multiple lumped capacitance modeling

Unit No: IV	**Transform Methods for Generalized Response**	**07 Hours**

Impulse response, Convolution integral: Response to arbitrary inputs when impulse response is known, Frequency response, Response to periodic Inputs, transient inputs and random signal.
Simulation Methods: Limitations of analytical methods, Analog Simulation.
Digital Simulation: Specific Digital Simulation techniques.

Unit No: V	**Generalized Modeling Methods & Applications of Distributed Parameter models**	**08 Hours**

Generalized Modeling Methods: Pulse testing methods, Random signal testing methods, Parameter tracking methods, Multiple regression and least square methods.
Applications of Distributed Parameter Models: Longitudinal vibrations of a rod, Lumped parameter approximations for rod vibration, Conduction, heat translation in an insulated bar, Magnetic levitation system for an Experimental Rail vehicle.

Learning Resources
1. Text Books
1. System Modeling and Response: Theoretical and Experimental Approaches. Ernest O. Dobling, John Wiley and Sons, 1980 2. Modeling and Simulation of Dynamic Systems: Robert Woods, Kent L. Lawrence, PrenticeHall. 3. William J. Palm, "Modeling Analysis and Control of Dynamic Systems", 2nd edition, 2013, Wiley
2. Reference Books
1. Simulation Modeling and Analysis: Averill M. Law, W. David Kelton. McGraw Hill 2. System Dynamics: Modeling Analysis, Simulation, Design: Ernest O. Dobling, Marcel Dekker Inc. 3. Modeling of Dynamical Systems Vol. I: H. Nicholson (Editor), Peter Peregrinus Ltd., onbehalf of IEE (Useful for unit 6) 116842, 1980 Edition 4. Dynamic Modeling and Control of Engineering Systems: J. Lowen Sheaser, Bohan T.Kulawski Macmillan Publishing Company NY, 158275, 1990 Edition
3. Links to online SWAYAM/NPTEL Courses
M1: https://nptel.ac.in/courses/11 /2104158 **M2:https://youtu.be/Nzs70wpd20A?si=3FQ7FT-xBIKKwfp2**

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3			2						2
CO2	3	2			3						
CO3	3	2	2		3						2
CO4	3	3		2	3						
CO5	3	3			2				2		1

Savitribai Phule Pune University
Board: Electrical Engineering
ME (Control Systems) (2025 Pattern)

Course code: PEC-522- COS		**Course Name:** Elective Lab-I
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 00 Hrs	--	TW : 25 Marks
Practical : 02 Hrs	01	OR : 25 Marks

Course Objectives:

1. To enable students to analyse and process discrete-time signals and systems using Z-transforms and digital filter techniques.
2. To develop competency in designing FIR and IIR filters using windowing, frequency sampling, and transform- based methods.
3. To introduce adaptive signal processing using LMS algorithms and explore real-time implementation on DSP hardware.
4. To provide practical skills in industrial automation through PLC programming, sensor interfacing, and actuator control.
5. To familiarize students with SCADA, DCS, and industrial communication protocols for process monitoring and control.

Course Outcomes: At the end of course, student will be able to

CO1. Analyse discrete-time signals and compute Z-transforms using MATLAB/Python.
CO2. Design and evaluate FIR and IIR digital filters for signal processing applications.
CO3. Implement adaptive filters like LMS and apply them to real-time signal processing problems.
CO4. Develop and test automation logic using PLCs and interface with industrial devices.
CO5. Design and simulate SCADA/DCS systems and configure communication using industrial protocols like MODBUS.

List of Experiments

- **Minimum of Eight (6) experiments should be performed under Elective Lab - 1 .**

Advanced Digital Signal Processing

1. Generation and Analysis of Discrete Time Signals
2. Z-Transform and Inverse Z-Transform Computation
3. FIR Filter Design using Window Techniques
4. Frequency Sampling Method for FIR Design
5. IIR Filter Design using Bilinear and Impulse Invariant Method
6. Implementation of LMS Adaptive Filter
7. Decimation and Interpolation of Signals
8. Polyphase Implementation of FIR Filters for Sampling Rate Conversion

The experiments can be carried out by using software tools like MATLAB/ Python. Experiments 6 to 8 can be an be extended to DSP boards (e.g., TI TMS320C6713) for real-time processing if available.

Industrial Automation and Control

PLC program using combination of timer and counter.

1. Study of Open Loop and Closed Loop Control Systems using Simulation Tools (MATLAB Simulink / Proteus / LabVIEW)
2. Interfacing Temperature and Proximity Sensors with Arduino/PLC (Arduino IDE / TinkerCAD / PLC hardware)

3. Control of DC Motor or Solenoid Using Actuators and Relay Module
4. PLC-based Traffic Light Control System using Ladder Logic (Siemens LOGO! Soft / Allen Bradley RSLogix / Factory I/O)
5. PLC-based Conveyor Belt System with Start/Stop and Emergency Logic
6. SCADA-Based Water Tank Level Monitoring and Control (iFIX, Wonderware, LabVIEW, or OpenSCADA)
7. Case Study or Demonstration of DCS for Process Control
8. Communication Between Two Devices using MODBUS RTU or TCP/IP (Modbus simulator (ModScan / ModSim) with PLC or RS485 modules)

Learning Resources

1. Text Books

[T1]. Sanjit K. Mitra – Digital Signal Processing: A Computer-Based Approach

[T2]. John G. Proakis & Dimitris K. Manolakis – Digital Signal Processing: Principles, Algorithms, and Applications

[T3]. Terry Borden & Richard Cox – Introduction to Programmable Logic Controllers

[T4]. T. R. Padmanabhan, Industrial Instrumentation, Springer India

[T5]. Rajesh A. Rajguru, SCADA: Supervisory Control and Data Acquisition, Shroff Publishers

2. Reference Books

[R1]. John W. Webb & Ronald A. Reis – Programmable Logic Controllers: Principles and Applications [R2]. S. Sundar Rajan, Modeling and Simulation Using MATLAB – Simulink, Mc Hall

[R3]. Ashwin Pajankar, Getting Started with Arduino and Raspberry Pi, BPB Publications

[R4]. Krishna Kant, Computer-Based Industrial Control, PHI Learning

3. E-Resources/ software tools

[E1]. MATLAB Signal Processing Toolbox https://www.mathworks.com/help/signal/

[E2]. Scilab + Scilab Signal Processing Toolbox https://www.scilab.org

[E3]. Octave DSP Toolkit https://wiki.octave.org/Signal_package

[E4]. Siemens TIA Portal & S7-1200 Manuals **https://support.industry.siemens.com**

[E5]. Allen-Bradley (Rockwell Automation) Manuals & RSLogix https://literature.rockwellautomation.com

सावित्रीबाई फुले पुणे विद्यापीठ

SEMESTER-II

Master of Engineering (2025 Pattern)

M.E. Electrical (Control Systems)

Savitribai Phule Pune University
Board: Electrical Engineering
ME (Control Systems) (2025 Pattern)

Course Code: PCC-551-COS		**Course Name:** Multivariable and Optimal Control System
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 4Hr/week	04	CCE : 50 Marks
Practical : --		ESE : 50 Marks

Prerequisite: Laplace and z-transform, Differential equations, Control systems, Electrical network, Nonlinear system, transfer function, state space analysis

Course Objectives: The course objectives are to

1. Apply MIMO technique in control system
2. Model various representations of MIMO system
3. Test various properties of MIMO system
4. Organize and design various types of observers
5. Examine various optimal methods with the solution

Course Outcomes: Upon successful completion of this course, the students will be able to:

1. Apply various MIMO techniques and representation in control system
2. Classify and compare various properties of MIMO System
3. Estimate and design various type of observers
4. List and formulate different types of optimal control methods
5. Design and optimize control system with an optimized solution

Course Contents

Unit No: I	**Multivariable Control Systems 1**	**10 Hours**

Example of multivariable control systems, differential operator and transfer matrix, state-space models and system solution, Controllability, Observability, State estimation, Pole allocation, Stability and reproducibility, Concept of state observer and disturbance observer, Evolution of state and disturbance observers a brief history.

Unit No: II	**Multivariable Control Systems 2**	**10 Hours**

Brief revision of Luenberger Observer, Limitations, Sliding Mode Observers: mathematical model of observer, robustness properties, procedure for gain selection, error analysis, stability, applications, advantages and limitations, Nonlinear ESO): mathematical model of observer, non-linear gain selection, Linear ESO, error analysis, applications

Unit No: III	**Optimal Control System 1**	**10 Hours**

Formulation of optimal control problem, Minimum time, energy, fuel problems, Calculus of variations, Minimization of functions, Control and state variable inequality constraints. Hamiltonian formulation of optimal control problem, Hamilton-Jacoby equation, Linear regulator problem.

Unit No: IV	**Optimal Control System 2**	**10 Hours**

Quadratic performance criterion, Time invariant state regulator, Numerical solution of Matrix Riccati Equation: Direct integration, a negative exponential method and iterative method, Pontryagin's minimum principle, application to optimal control of discrete and continuous systems.

Unit No: V	**Optimal Control System 3**	**10 Hours**

Suboptimal linear regulators: Continuous time and discrete time systems, Minimum time control, normality and existence uniqueness of control, Bang-Bang Control, singular solutions.

Learning Resources
1. Text Books
1. "Linear Multivariable Control System. S. Apte, New Age International Publication 1996 2. "Multivariable Control System. M. Wonham, Springer-Verlag, 1985 3. "Optimal Control-An Introduction": O. Kirk, Prentice Hall 4. "Optimum Systems Control", P. Sage, II Edition 5. "Sliding Mode Control: Theory and Applications", C. Edwards, S. Spurgeon, CRC Press 6. "Disturbance Observer-Based Control: Methods and Applications",Shihua Li, Jun Yang, Wen-Hua Chen, Xisong Chen, CRC Press.
2. Reference Books
1. "Linear System Theory and Design",C. T. Chen, 3rd Edition, Oxford 1999 2. "Multivariable Control", N. K. Sinha, Marcel Dekker Inc., New York 3. "Control System Design",Goodwin, Graebe, Salgado 4. "Optimization Theory and Applications",S. Rao, Wiley Eastern 5. Wang, W. and Gao, Z., 2003, June. A comparison study of advanced state observer design techniques. In *American Control Conference, 2003. Proceedings of the 2003* (Vol. 6, pp. 4754-4759). IEEE.
3. Links to online SWAYAM/NPTEL Courses
M1: https://archieve.nptel.ac.in/courses/108/107/108107098. **M2: https://onlinecourses.nptel.ac.in/noc21_ma10/** **M3: https://onlinecourses.nptel.ac.in/noc21_ee48/**

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3			2						2
CO2	3	2			2						
CO3	3	3	2		3						2
CO4	3	3		3	2						
CO5	3	2			2				1		2

Savitribai Phule Pune University
Board: Electrical Engineering
ME (Control Systems) (2025 Pattern)

Course Code: PCC-552-COS		**Course Name:** Control of power electronic circuits	
Teaching Scheme		**Credits**	**Examination Scheme**
Theory	: 4Hr/week	04	CCE : 50 Marks
Practical	: --		ESE : 50 Marks
Tutorial	: --		PR : --

Prerequisite: Power Electronics, Control systems, Linear Systems, Electrical Network, Analog and Digital Electronics

Course Objectives: Course objectives are to

1. Introduce various types models used for control design in power electronics
2. Design controller for the power electronic converter using modern control theory
3. Introduce sliding mode control and embedded control as a tool for controller design

Course Outcomes: After the successful completion of this course, the student will be able to

1. Choose suitable power electronics model for the controller design ü
2. Acquire knowledge about control principle, goal and issues in the Power electronic converters.
3. Develop model of DC-Dc converter for control design purpose.
4. Design controller for DC-DC converter based on modern control techniques
5. Devise sliding mode controller for the power electronic circuit.
6. Understand implementation of power electronic control circuit using embedded systems.

Course Contents

Unit No: I	**Introduction**	**10 Hours**

Introduction: Role and Objectives of Power Electronic Converters, Requirements of Modelling, Simulation and Control of Power Electronic Converters, Models, Model Types: Switched Models, sampled-Data Models, Averaged Models, Large-Signal and Small-Signal Models, Behavioural Models, Relations Between Various Types of Models, Relations Between Modelling and Control

Unit No: II	**General Control Principles**	**10 Hours**

General Control Principles of Power Electronic Converters, Control Goals in Power Electronic Converter Operation, Specific Control Issues Related to Power Electronic, Different Control Families

Unit No: III	**Modelling of DC-to-DC Power Converters**	**10 Hours**

Introduction, the Buck, Boost, Buck-Boost Converter, Model of the Converter Normalization, Equilibrium Point and Static Transfer Function, Prototype.

Unit No: IV		**10 Hours**

Linear Feedback Control for buck, book and buck-boost converter, Pole Placement by Full State Feedback, Pole Placement Based on Observer Design, Reduced Order Observers, Flatness, Generalized Proportional Integral Controllers, Passivity Based Control, A Hamiltonian Systems Viewpoint.

Unit No: V	**Linear Control Approaches for DC-AC and AC-DC Power Converters**	**10 Hours**

Introductory Issues, Control in Rotating dq Frame Resonant Controllers, Necessity of Resonant Control, Basics of Proportional-Resonant Control, Design Methods, Implementation Aspects Control of Full-Wave Converters, Introduction, Sliding Surface, General Theoretical Results, Reachability of the Sliding Surface: Transversality Condition, Equivalent Control, Dynamics on the Sliding Surface, Variable-Structure Control Design, General Algorithm, Application Example

Learning Resources
1. Text Books
1. Jai P. Agrawal, Power Electronic Systems: Theory and Design — (Pearson Education, India) **2.** P. S. Bimbhra -Power Electronics (7th Edition**)** 3. Moleykutty George & Jagadeesh Pasupuleti, Modeling, Stability Analysis, and Control of a Buck Converter
2. Reference Books
R1. Power Electronic Converters Modelling and Control with Case Studies, Seddik Bacha Iulian Munteanu Antoneta Iuliana Bratcu, Springer R2. Control Design Techniques in Power Electronics Devices, Hebertt Sira-Ramírez and Ramón Silva-Ortigoza, Springer R3. Control Systems for Power Electronics A Practical Guide, Mahesh Patil Pankaj Rodey, Springer R4. Ned Mohan et.al "Power electronics: converters, applications, and design" John Wiley and Sons, 2006 R5. Rashid "Power Electronics" Prentice Hall India 2007. R6. G.K.Dubey et.al "Thyristorised Power Controllers" Wiley Eastern Ltd., 2005, 06.
3. Links to online SWAYAM/NPTEL Courses
M1: https://archieve.nptel.ac.in/courses/108/107/108107098. **M2: https://onlinecourses.nptel.ac.in/noc21_ma10/** **M3: https://onlinecourses.nptel.ac.in/noc21_ee48/**

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3			2						2
CO2	3	2			2						
CO3	3	3	2		3						2
CO4	3	3		3	2						
CO5	3	2			2				1		2

Savitribai Phule Pune University
Board: Electrical Engineering
ME (Control Systems) (2025 Pattern)

Course Code: PCC-553-COS	**Course Name:** Digital Signal Processing and its Applications	
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 4Hr/week	04	CCE : 50 Marks
Practical : --		ESE : 50 Marks

Prerequisite: Fourier series, Fourier transform Z transform

Course Objectives: The course objectives are to

Course Outcomes: After the successful completion of this course, the student will be able to

1. Classify discrete time signal and system and determine Z and inverse Z-transform of DTS.
2. Determine frequency response of first and second order LTI system with phase and group delay.
3. Derive frequency response of DTS using DTFT and DFT.
4. Design and realize IIR filter using different techniques.
5. Design and realize IIR filter using different window techniques.
6. Apply basics of DSP in different applications of electrical engineering.

Course Contents

Unit No: I	Discrete Signals and systems & Z transform	**10 Hours**

A) Discrete Signals and systems: Sampling of continuous time signals, quantization, aliasing, Sampling Theorem, Elementary discrete-time signals, classification, sequence operations, Discrete time systems and classification, impulse response, linear convolution and its properties, Discrete time systems described by difference equations.
B) Z transform: Definition, basics, properties, inverse Z-transform using power series and partial fraction Solution of difference equation, Analysis of LTI system

Unit No: II	**Frequency analysis of discrete time signals**	**10 Hours**

A) Discrete Time Fourier Transform: Frequency response of DTS, Discrete frequency spectrum and range, DTFT Definition and its properties. Numerical.
B) Discrete Fourier Transform: Definition and Properties of DFT, Circular convolution, Linear convolution using circular convolution, Fast Fourier Transform: Radix 2 DIT and DIF algorithms

Unit No: III	**Time and Frequency response of discrete time system**	**10 Hours**

A) Time Response: Natural response, forced response and total response, impulse response and step response
B) Frequency response: frequency response of first order and second order systems, transfer function, steady state and transient response, phase and group delays, ideal filters and their pole zero locations, zero phase and linear phase transfer functions

Unit No: IV	**IIR filters**	**10 Hours**

Advantages and disadvantages of digital filter over analog filters, classification of digital filters: FIR and IIR, design of analog low pass Butterworth filter, Chebyshev filter, design of IIR filters from analog filters using bilinear transformation, impulse invariance. Realization of IIR filters: direct form I, direct form II, cascade and parallel.

Unit No: V	**FIR filters & Applications of DSP**	**10 Hours**

Comparison between FIR and IIR filters, symmetric and antisymmetric FIR filters, design of linear phase FIR filters using windows method (rectangular, Hanning and Kaiser), Applications of DSP 1) Measurement of power 2) Measurement of frequency 3)Condition monitoring and speed control of Electrical Machines

Learning Resources
1. Text Books
T1. Mitra S., "Digital Signal Processing: A Computer Based Approach", Tata McGraw-Hill, 1998, ISBN 0-07-044705-5 T2. Proakis J., Manolakis D., "Digital signal processing", 3rd Edition, Prentice Hall, ISBN 81- 203-0720-8 T3. P.RameshBabu "Digital Signal Processing" 4th Edition, Scitech Publication, Chennai
2. Reference Books
R1. Oppenheim A., Schafer R., Buck J., "Discrete time signal processing", 2nd Edition, Prentice Hall, 2003, ISBN-81-7808-244-6 R2. Rebizant, Waldemar, Szafran, Janusz, Wiszniewski, Andrzej, "Digital Signal Processing in Power System Protection and Control", 1st Edition. Springer, 2011, ISBN 0857298011, 9780857298010
3. Links to online SWAYAM/NPTEL Courses
M1: https://archieve.nptel.ac.in/courses/108/107/108107098. **M2: https://onlinecourses.nptel.ac.in/noc21_ma10/** **M3: https://onlinecourses.nptel.ac.in/noc21_ee48/**

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3			2						2
CO2	3	2			2						
CO3	3	3	2		3						2
CO4	3	3		3	2						
CO5	3	2			2				1		2

Savitribai Phule Pune University
Board: Electrical Engineering
ME (Control Systems) (2025 Pattern)

Course Code: PCC-554- COS		**Course Name:** Laboratory Practice – II
Teaching Scheme	**Credits**	**Examination Scheme**
Practical : 4 Hrs/week	02	TW : 25 Marks
		PR : 25 Marks

A minimum eight experiments should be performed under Lab Practice – II. Out of which minimum six experiments should be from the list below. Minimum six experiments should be based on compulsory subjects. A list of experiments that may be performed under various subjects of semester -II is given below as a guideline:

1. **Multivariable and Optimal Control Systems**

a) Representation of multivariable control system in S.S, D.O and T. M. form.
b) Pole placement using linear state variable form
c) Numerical solution of matrix Riccati equation.
d) Full order observer design/minimum time (Bang-Bang) control.

2. **Control of Power Electronic Circuits**

a) To design sliding mode control for any power electronic converter using MATLAB/LabView
b) To design of controller using pole placement/observer for DC-DC converter using MATLAB
c) To understand effect of unbalanced voltage on power electronic converter using power analyzer

3. **Digital Signal Processing and its Applications**

a) Verification of linear and circular convolution in MATLAB
b) To find the DFT and IDFT of a sequence in MATLAB.
c) To design a filter for a signal mixed with noise.
d) To generate a PWM signal using any digital signal processor.
e) To design a discrete PID controller for an application

Savitribai Phule Pune University
Board: Electrical Engineering
ME (Control Systems) (2025 Pattern)

Course Code: PEC-561 A-COS		**Course Name:** Robust Control Systems
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 3Hr/week	03	CCE : 50 Marks
Practical : --		ESE : 50 Marks

Prerequisite: Matrices, Linear Algebra, Control Systems, Optimal Control, optimization techniques

Course Objectives: The course objectives are to

1. Introduce some common robust problems
2. Understand H infinity controller for continuous and discrete systems
3. Introduce robust and perfect tracking of continuous time and discrete time systems

Course Outcomes: Upon successful completion of this course, the students will be able to:

1. Identify common robust problems
2. Understand mapping of continuous time to discrete time and vice-a-versa
3. Get the solution of discrete time Riccati equations
4. Appreciate H infinity optimization in continuous and discrete time system

Course Contents

Unit No: I	**Introduction**	**08 Hours**

Robust control problems. Linear system tools: Jordan and Real Jordan canonical forms, structural decomposition, Problems on structural decomposition.

Unit No: II	**Structural mapping of Bilinear Transformations and Solution to Discrete time Riccati Equations**	**08 Hours**

Structural mapping of Bilinear Transformations: Mapping of continuous time to discrete time and vice a versa, existence condition of H∞ sub optimal controllers, continuous time system and discrete time system.
Solution to Discrete time Riccati Equations: Solutions to general DARE and H∞ -DARE.

Unit No: III	**Information in continuous time and discrete time H ∞ optimization**	**08 Hours**

Full information feedback, output feedback, plants with imaginary axis zeros/unit circle zeros.

Unit No: IV	**Solutions to continuous time and discrete time H ∞ problems 1**	**08 Hours**

Full state feedback, full order output feedback, reduced order output feedback and mathematical problems on reduced order output feedback strategy.

Unit No: V	**Solutions to continuous time and discrete time H ∞ problems 2**	**08 Hours**

Robust and perfect tracking of continuous time and discrete time systems, solvability conditions and solutions; solutions to measurement feedback

Learning Resources

1. Text Books

T1: Robust and H ∞ Control: Ben M. Chen, Springer Verlag, London, 2000
T2: Essentials of Robust Control: K. Zhon, John C. Doyle, Prentice Hall Int. 1998

2. Reference Books

R1: Robust Control - The Parametric Approach: S. P. Bhattacharya, H. Chapellat, Prentice Hall Int. 1995
R2: Robust Adaptive Control: Petros A. Ioannou, Jing Sun, Prentice Hall Int. Upper Saddle River, NJ07458
R3: Robust Process Control: M. Morari and E. Zafiriou, Prentice Hall 1989
R4: Feedback Control Theory: J. C. Doyle, B. A. Francis and A. R. Tannenbaum, Macmillan 1992.
R5: A Course in H ∞ Control Theory: Francis
R6: Optimal Controller, A General Robust Control in Control System Toolbox:- Robust Analysis,
R7:Robust Model Reduction:- MATLAB, Mathwork Inc. 1992.

3. Links to online SWAYAM/NPTEL Courses

M1: https://archieve.nptel.ac.in/courses/115/108/115108104
M2: https://onlinecourses.nptel.ac.in/noc24_ee90/

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2			2						2
CO2	3	2			2						
CO3	3	3	3		3						3
CO4	3	2		2	3						
CO5	3	2			3				2		2

Savitribai Phule Pune University
Board: Electrical Engineering
ME (Control Systems) (2025 Pattern)

Course Code: PEC-561B-COS		**Course Name:** Large Scale System
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 3Hr/week	03	CCE : 50 Marks
Practical : --		ESE : 50 Marks
Tutorial : --		PR : --

Prerequisite: Formulation and solution of mathematical models in engineering and science Applications, Reduce order system, Knowledge of matrices

Course Objectives: The course objectives are to

1. Study of interconnected feedback systems with a detailed engineering interpretation of the relevant methods and results.
2. Study different approaches, which have led to the large number of available analytical and design methods and many recent results.
3. Study of interrelationships of methods, advantages and drawbacks.

Course Outcomes: Upon successful completion of this course, the students will be able to:

1. Understand large scale system.
2. Study methods to reduce order of system.
3. Learn different aggregation methods.
4. Understand frequency based system for model order reduction.

Course Contents

Unit No: I	**Modeling and parameter estimation**	**08 Hours**

Introduction to probability theory, elements of estimation theory, application to parameter estimation for a dynamical model, methods for the determination of transfer functions, Hierarchical parameter estimation, multiple projection approach, Recursive algorithm for the minimum variance estimator.

Unit No: II	**Aggregation**	**08 Hours**

Aggregation of control systems, problem statement, properties of the aggregated system matrix, determination of the Aggregation matrix; Generation of feedback controls: linear dynamic optimization, bounds on sub optimality, eigenvalue assignment.

Unit No: III	**Model reduction techniques**	**08 Hours**

Model analysis approach, mathematical development, three basic methods, and a general approach, Subspace projection methods, projection error minimization, and derivation of reduced model. Optimal order reduction, problem formulation, conditions of optimality, numerical algorithm, polynomial input functions. A comparative study. Extension to discrete systems, preliminary analysis, two model reduction techniques, output error minimization. Examples.

Unit No: IV	**Model Simplifications**	**08 Hours**

Model simplification using frequency domain techniques. Simplification by continued function expansions: three Cauer forms, a generalized Routh algorithm, simplified models, relationship to aggregation, and extension to discrete models; Approximation methods for simplification: time moment matching, Padetype approximations, Routh-Hurwitz method. Minimal realization algorithms: conditions of reliability, Pade – type realizable models, aggregated model of Routh approximants.

Unit No: V	**Time scale analysis**	**08 Hours**

Block-diagonalization of continuous systems: problem statement, numerical algorithms, basic properties, relation to model aggregation. Feedback control design: two stage eigenvalue placement. Decoupling of discrete systems:, state feedback design.

Learning Resources

1. Text Books

T1: Magdi S. Mahmoud and Madan G. Singh – "Large scale systems modeling", Pergamon press, Oxford.
T2: LanLunze – "Feedback control of Large scale system s", Prentice Hall International, New York.
T3: Prof. B. Bandopadhyay – "Large scale systems"

2. Reference Books

R1: Magdi S. Mahmoud, Mohamed F. Hassan, Mohamed G. Darwish- "Large scale control systems - Theories and Techniques", Marcel Dekkar, Inc, New Y ork and Basel.
R2: Yacov Y. Haimes – "Large scale systems", Publisher: North Holland publishing Co. Amsterdam.
R3: Dragoslav D. Siljak – "Large scale dynamic systems: stability and structure", Norht Holland, New York.
R4: International federation of automatic control (IFAC) symposia series, 1990, No. 9, "Large scale systems: theory and applications 1989.

3. Links to online SWAYAM/NPTEL Courses

M1: https://youtu.be/dbbVcRNTbgw?si=W8pu6GEpKQQQT2g-r

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3			2						1
CO2	3	2			2						
CO3	3	2	2		2						3
CO4	3	1		2	2						
CO5	3	2			3				1		1

Savitribai Phule Pune University
Board: Electrical Engineering
ME (Control System) (2025 Pattern)

Course Code: PEC-562A C-COS		**Course Name:** Advanced Digital Control Techniques
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 3 Hr/week	03	CCE : 50 Marks
Practical : --		ESE : 50 Marks
Tutorial : --		PR : --

Prerequisite: Basics of digital control systems, MATLAB Programming, Observability and Controllability, signal processing

Course Objectives: The course objectives are to

1. Introduce application of DSP processors in control design implantation
2. Understand implantation of digital P, PI and PID controllers
3. Realize digital control methods in modern control systems

Course Outcomes: Upon successful completion of this course, the students will be able to:

1. Learn digital modeling with sample and hold devices.
2. Analyze significance of P, PI PID controllers as well as lag, Lead Compensators.
3. Design full order observer by separation principle.
4. Explain design of FIR and IIR Filters with their applications.
5. Classify TMS 320C5X And TMS320C54X.DSP Processors and Learn DSP application human EEGs.

Course Contents

Unit No: I	**Digital Redesign**	**08 Hours**

Introduction, Digital modeling with sample and hold devices, State variable formulation, Numerical integration, Frequency domain characteristics, Warping and Prewarping, Digital Redesiging, Closed form solution for Digital System, Partial matching of states.

Unit No: II	**Design of Discrete Data control Systems**	**08 Hours**

Design in the Z plane using root locus diagram, Digital P, PI, PID controller, Design of Discrete Data System using Z-Transform method, Simple lag, lead and lag-lead compensators. Pole zero cancellation.

Unit No: III	**Pole Placement Design and State Observer**	**08 Hours**

State regulator design, Design of full State Observers, Design by separation principle. State feedback with integral control, digital control system with state feedback, deadbeat observer, Concept of Adaptive Control.

Unit No: IV	**Multirate Digital Signal Processing**	**08 Hours**

Multirate DSP, Decimation, Interpolation, Design of Practical Sampling, Rate Conversion, Design of FIR and IIR Filters, Finite word length effect in digital filters, discrete wavelet transform, adaptive filter components, algorithms.

Unit No: V	**Digital Signal Processor and Applications**	**08 Hours**

Digital Signal Processors - Features, Fixed and Floating point DSP, Selection of DSP. Architecture and Instruction set of TMS 320C5X, instruction pipelining, DSP applications, detection of fetal heartbeats during labour, Adaptive removal of ocular artefacts from human EEGs, Equalization of digital audio signals. Design studies.

Learning Resources
1. Text Books
1. Discrete Time Control Systems, Pearson Education Asia, Katsuhiko Ogata. 2. Digital Control and State Variable Methods (conventional and Neuro Fuzzy Control), Tata McGraw Hill, M. Gopal 3. Digital Signal Processing Implementation using DSP Microprocessors with Examples from TMS 320C54XX, Thomas Publication, Avatar Singh, S. Srinivasan 4. Digital Signal Processor, B. Venkatramani, M. Bhaskar, Tata McGraw Hill
2. Reference Books
1. Digital Control Systems, Oxford Press, Koop 2. Digital Signal Processing, Principles, Algorithms and Applications, Pearson Education, John G Proakis 3. Digital Signal Processing, Pearson Education, Ifeachar Jervis
3. Links to online SWAYAM/NPTEL Courses
M1: https://nptel.ac.in/courses/108103008

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2			2						2
CO2	3	2			3						
CO3	3	3	2		3						3
CO4	3	2		1	2						
CO5	3	2			3				2		2

Savitribai Phule Pune University
Board: Electrical Engineering
ME (Control Systems) (2025 Pattern)

Course Code: PEC-562B C-COS	**Course Name:** Modern Control Systems

Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 3Hrs/week	03	CCE : 50 Marks
Practical : --		ESE : 50 Marks

Prerequisite: Advance control systems, MATLAB Programming, Observability and Controllability

Course Objectives: The course objectives are to

1. Analyze dynamics of a linear system by State Space Representation.
2. Determine the stability of a linear system using pole-placement technique.
3. Design State Observers.

Course Outcomes: Upon successful completion of this course, the students will be able to:

1. Analyze basics of Non-linear control system.
2. Determine the stability of Non-linear systems.
3. Formulate and solve deterministic optimal control problems in terms of performance indices.
4. Realize the structure of a discrete time system and model its action mathematically.

Course Contents

Unit No: I	**STATE SPACE ANALYSIS**	**08 Hours**

The Concept of State and State Models, State Diagram, State Space and State Trajectory, State Space Representation using Phase Variable and Canonical Variables, Solution of State Equation, State Transition Matrix and its Properties, Eigen Values, Eigen Vectors, Model Matrix, Diagolization, Generalized Eigen vectors, Computation of State Transition Matrix using Laplace Transformation, Power Series Method, Cayley-Hamilton Method, Similarity Transformation Method.

Unit No: II	**POLE PLACEMENT TECHNIQUES**	**08 Hours**

Controller Design by State Feedback, Necessary and Sufficient Condition for Arbitrary Pole Placement-State Regulator Problem and State Regulator Design, Evaluation of State Feedback Gain Matrix K, Selection of Location of Desired Closed Loop Poles, State Observer Design, Full Order/Reduced Order Observer Design, Observer Based State Feedback Control, Separation Principle.

Unit No: III	**NONLINEAR CONTROL SYSTEM**	**08 Hours**

Introduction, Properties of Nonlinear System, Behavior of Non-Linear System, Classification of Nonlinearities, Common Physical Nonlinearities: Saturation, Friction, Backlash, Dead-Zone, Relay, On-Off Nonlinearity, Nonlinear Spring, Limit cycle, Jump resonance. Phase-Plane Method, Singular points, Stability of Nonlinear System, Construction of Phase Trajectories, Describing Functions Method, Stability Analysis by Describing Function Method. Lyapunov's Stability Analysis

Unit No: IV	**OPTIMAL CONTROL**	**08 Hours**

Introduction to Optimal Control, Parameter Optimization: Servomechanism, Optimal Control Problem: Transfer Function and State Variable Approach, State Regulator Problem, Infinite Time Regulator Problem, Output Regulator and the Tracking Problem, Parameter Optimization: Regulators

Unit No: V	**DIGITAL CONTROL SYSTEMS**	**08 Hours**

Introduction to Discrete Time Systems, Necessary for Digital Control System, Spectrum Analysis of Sampling Process, Signal Reconstruction, Difference Equations, Z transforms, and the Inverse Z transform, Pulse Transfer Function, Time Response of Sampled Data Systems, Stability using Jury Criterion, Bilinear Transformation.

Learning Resources
1. Text Books
T1. Katsuhiko Ogata, Modern Control Engineering Prentice-Hall of India, New Delhi. T2. I. J. Nagarath and M. Gopal, Control system Engineering, New Age International (P) Ltd. T3. Katsuhiko Ogata, State Space Analysis of Control Systems, Prentice Hall Inc, New Jersey. T4. Benjamin C. Kuo and Farid Golnaraghi, Automatic Control Systems, 8th Edition, John Wiley & Sons. T5. H. Khalil, Nonlinear Control systems, Prentice Hall Inc, New Jersey.
2. Reference Books
R1. Brogan W. L., Modern Control theory, Prentice Hall International, New Jersey. R2. Jean-Jacques E, Slotine, Weiping Li, Applied Nonlinear Control, Prentice Hall Inc., New Jersey. R3. Donald Kirk, Optimal Control Theory, an Introduction, Prentice Hall, Inc, Englewood Cliffs, New Jersey. R4. Brain D., Anderson and J. B. Moore, Optimal Control, Prentice Hall. R5. Andrew P., Sage, Optimum Systems Control, Prentice Hall. R6. M. Gopal , Digital Control & State Variable Methods, TMH. R7. A. Nagoor Kani, Control System, RBA Publications.
3. Links to online SWAYAM/NPTEL Courses
M1: https://nptel.ac.in/courses/108103008

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2			2						2
CO2	3	2			3						
CO3	3	3	2		3						3
CO4	3	2		1	2						
CO5	3	2			3				2		2

Savitribai Phule Pune University
Board: Electrical Engineering
ME (ELECTRICAL ENGINEERING) (2025 Pattern)

Course Code SEM-581-COS		**Course Name: Technical Seminar-I**
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 00 Hrs	--	TW : 25 Marks
Practical : 04 Hrs	02	OR : 25 Marks

Course Description:
The seminar aims to enhance students' research, presentation, and critical thinking skills, preparing them for advanced academic pursuits and professional careers.

The objectives are,

1. **Deepen Technical Knowledge**: To enable students to explore a specialized topic within Electrical Engineering beyond the regular curriculum, fostering in-depth understanding.
2. **Develop Research Skills**: To provide practical experience in identifying, acquiring, evaluating, and synthesizing information from various technical sources (research papers, standards, technical reports).
3. **Enhance Communication Skills**: To cultivate effective oral and visual presentation skills, enabling students to articulate complex technical concepts clearly and concisely to a knowledgeable audience.
4. **Foster Critical Thinking:** To encourage students to critically analyze existing research, identify challenges, propose solutions, and engage in constructive discussions.
5. **Promote Independent Learning**: To encourage self-directed learning and the ability to stay updated with emerging technologies and research trends.
6. **Prepare for Thesis/Dissertation:** To serve as a foundational step for the Master's thesis/dissertation, allowing
students to explore potential research areas.

Course Outcomes: At the end of the course, the student will be able to

1. **CO1:** Formulate the goals and objectives of scientific research.
2. **CO2:** Search, evaluate and analyze information about the achievements of science and technology in the target area and beyond.
3. **CO3**: Interpret data from different fields of science and technology.
4. **CO4:** Build the logic of reasoning and statements.
5. **CO5:** Create, design and edit text documents in accordance with the requirements of the organization or publisher.

Course description

- **Responsibility of the students**
  - The Seminar should be carried out individually by each student.
  - A student should identify the area or topics in recent trends and developments in consultation with the guide
  - A student should report to his/her respective guide regularly (at least once a week) and report the progress of the seminar work.
  - A student should follow the timelines and deadlines and inform the supervisor in case of any difficulty/delay.
  - Students should maintain the record of all the meetings, remarks given by guide/reviewers and progress of the work in the project diary. The project diary must be presented during each review presentation to the reviewers.

- A student should conduct the research ethically, adhere to the academic integrity standards, and cite sources
  whenever using any existing results
- A student should Incorporate constructive feedback to improve the quality and rigor of the research
- For final examination, students should complete the Seminar Report in all aspects including formatting and citation.
- Each student should prepare the report, get it approved by his/her guide and submit the duly signed copy within the deadline.
- A student should invest time and effort in preparing seminar presentations and the oral defense of the seminar

- **Topic Selection**
  - **Relevance:** Topics must be directly related to Electrical Engineering, encompassing cur- rent research trends, emerging technologies, advanced concepts, or interdisciplinary applications
  - **Scope:** The topic should be sufficiently focused to allow for in-depth exploration within the seminar timeframe, yet broad enough to demonstrate a comprehensive understanding. Avoid overly narrow or excessively broad topics.
  - **Novelty (Desired):** While not strictly a research paper, students are encouraged to explore topics that have recent advancements, open problems, or areas where their unique insights can be presented. Avoid merely summarizing introductory textbook material.
  - **Guide / Supervisor Approval**: Each student must select a seminar topic in consultation with and obtain approval from an assigned faculty supervisor. The supervisor will guide the student in refining the topic and identifying relevant resources.
  - **Examples of Broad Areas:** Optimization Techniques in Control System, Automation in Manufacturing, System Identification and Adaptive Control, Industrial Automation and Control, Automation and Robotics, Modelling of Dynamic System, Control of Power Electronics Circuits, Digital Signal Processing and its Applications, Modern Control Systems
- **Seminar Structure and Deliverables:**
  The technical seminar typically involves the following stages and deliverables
  - Topic Proposal (2-3 weeks after topic approval):
  - A concise document (1-2 pages) outlining:
  - Proposed Seminar Title
  - Brief Description/Abstract of the Topic
  - Motivation and Relevance to Electrical Engineering
  - Preliminary List of Key References (at least 5-7 reputable sources)
  - Tentative Scope and Outline of the Presentation
  - Submission: To the faculty supervisor for approval.
  - Literature Review and Research (Ongoing): Sources: Students must primarily rely on peer-reviewed academic sources (IEEE Xplore, ACM Digital Library, SpringerLink, arXiv, Google Scholar), reputable conference proceedings, and established industry standards. Wikipedia and unverified blogs are generally not acceptable as primary sources.
  - Critical Analysis: Beyond mere summarization, students are expected to critically analyze the literature, identifying different approaches, their advantages/disadvantages, open issues, and potential future directions.
  - Note-Taking & Organization: Maintain systematic notes and organize research material effectively.
- **Seminar Report**

- A written report (typically 15-25 pages, excluding references and appendices) detailing the seminar content.
- Format: Follow a professional academic paper format (e.g., IEEE transaction style).
- **Sections**
  - **Abstract:** A concise summary of the seminar topic and key findings.
  - **Introduction**: Background, motivation, problem statement (if applicable), and outline of the report.
  - **Literature Review/Background**: Detailed discussion of relevant concepts, theories, and existing work.
  - **Core Content:** In-depth exploration of the chosen topic, presenting different methodologies, architectures, algorithms, or challenges as relevant.
  - **Analysis/Discussion**: Critical evaluation of the presented material, comparing different approaches, discussing implications, and identifying gaps.
  - **Future Trends/Conclusion:** Summarization of key takeaways, potential future directions, and concluding remarks.
  - **References:** A comprehensive list of all cited sources properly formatted.
  - Appendices (Optional): Supplementary material if necessary.

- **Oral/ Presentation**
  - Duration: Typically, 25-30 minutes for presentation, followed by 10-15 minutes for Q&A. (Specific timings will be announced)
  - Audience: Faculty members, peers, and potentially other interested individuals.
  - Content: The presentation should effectively convey the key aspects of the seminar topic.
  - It should not simply be a reading of the report.
  - Visual Aids: High-quality presentation slides (e.g., PowerPoint, Google Slides, LaTeX Beamer) are mandatory. Slides should be clear, concise, visually appealing, and support the oral delivery. Avoid excessive text on slides.
  - Delivery: Clear articulation, confident posture, good eye contact, and appropriate pace.
  - Practice the presentation thoroughly.
  - Q&A Session: Be prepared to answer questions from the audience on all aspects of the seminar topic. Demonstrate a strong understanding and ability to defend your perspectives.

- **Evaluation Criteria:** The technical seminar will be evaluated based on the following criteria:
  - Topic Selection and Scope (10%): Relevance, timeliness, and appropriate depth of the chosen topic. Clarity and focus of the topic proposal.
  - Literature Review and Research (25%): Breadth and depth of literature surveyed. Quality and credibility of sources used. Critical analysis and synthesis of information.
  - Seminar Report/Paper (30%): Clarity, organization, and logical flow of content. Technical accuracy and depth of discussion. Adherence to academic writing standards (grammar, spelling, formatting, referencing). Originality in synthesis and critical insights. Absence of plagiarism.
  - Oral Presentation (35%): Content: Clarity, completeness, and accuracy of the presented material. Organization: Logical flow, effective use of time. Visual Aids: Quality, clarity, and effectiveness of slides. Delivery: Confidence, clarity of speech, enthusiasm, engagement with the audience. Q&A: Ability to answer questions accurately, comprehensively, and confidently.

Learning Resources
Textbooks
[T1]. "Engineering Communication" by Charles W. Knisely & Karin I. Knisely [T2]. "Technical Communication: Principles and Practice" by Meenakshi Raman & Sangeeta Sharma [T3]. "The Craft of Scientific Presentations" by Michael Alley
Swayam/ NPTEL Courses
[1]. https://nptel.ac.in/courses/109/106/109106180/ [2]. https://www.udemy.com/course/technical-writing/ [3]. https://www.edx.org/course/writing-in-the-sciences

सावित्रीबाई फुले पुणे विद्यापीठ

SEMESTER-III

Master of Engineering (2025 Pattern)

M.E. Electrical (Control Systems)

Savitribai Phule Pune University
Board: Electrical Engineering
ME (ELECTRICAL ENGINEERING) (2025 Pattern)

Course Code: RM-601-COS		**Course Name:** Research Methodology	
Teaching Scheme		**Credits**	**Examination Scheme**
Theory	: 04 Hrs	04	CCE : 50 Marks
Practical	: 00 Hrs	--	ESE : 50 Marks

Prerequisite:

1. Familiarity with project-based learning (e.g. mini projects, seminars, undergraduate theses)
2. Knowledge of basic statistics (mean, median, variance, standard deviation, probability concepts)
3. Basic skills in technical writing (reports, presentations, documentation).
4. Sound fundamentals of the core engineering/science domain

Course Objectives:

1. Understand the philosophy of research in general
2. Understand basic concepts of research and its methodologies
3. Learn the methodology to conduct the Literature Survey
4. Acquaint with the tools, techniques, and processes of doing research
5. Learn effective report writing skills and allied documentation
6. Become aware of ethics in research, academic integrity and plagiarism

Course Outcomes:

1. CO1: Define research and explain its essential characteristics with examples from engineering and science fields.
2. CO2: Identify and apply different types of research (basic, applied, qualitative, quantitative, exploratory, descriptive, etc.) to specific problems.
3. CO3: Analyse the outcomes of research such as publications, patents, and technological contributions, and understand their societal and industrial impacts.
4. CO4: Apply ANOVA and ANCOVA techniques for effective experimental data analysis and interpretation of results.
5. CO5: Understand and apply the basics of Intellectual Property Rights (IPR) to safeguard innovative research and prevent unethical practices.

Course Contents

Unit No: I	**Definition and Characteristics of Research**	**10 Hours**

Basic of Research: Definition; Concept of Construct, Postulate, Proposition, Thesis, Hypothesis, Law, Principle. Philosophy and validity of research. Objective of research. Various functions that de- scribe characteristics of research such as systematic, valid, verifiable, empirical and critical approach. Types - Pure and applied research. Descriptive and explanatory research. Qualitative and quantitative approaches.

Engineering Research: Why? Research Questions, Engineering Ethics, conclusive proof-what constitutes, A research project-Why take on?

Case Study: Code of Ethics, IEEE Code of Ethics, ACM Software Engineering Code of Ethics and Professional Practice, Code of Ethics especially covering Engineering discipline, various aspects- environment, sustainable outcomes, employer, general public, and Nation, Engineering Disasters.

Unit No: II	**Literature Search and Review**	**10 Hours**

Literature Review, Types of Review, Developing the objectives, Preparing the research design including sample

Design, Sample size. Archival Literature, why should engineers be ethical? Types of publications- Journal papers, conference papers, books, standards, patents, theses, trade magazine, newspaper article, infomercials, advertisement, Wikipedia & websites, Measures of research impact, publication cost.

Case Study: Engineering dictionary, Shodhganga, The Library of Congress, Research gate, Google Scholar, Bibliometrics, Citations, Impact Factor, h-index, I-index, plagiarism, copyright infringement

Unit No: III	Analysis of Variance and Covariance	10 Hours

Basic principle of Analysis of Variance, ANOVA Technique, Setting up Analysis of Variance Table, short-cut method for oneway ANOVA, Coding method, Two-way ANOVA, ANOVA in Latin-square design, analysis of co-variance (ANCOVA), assumptions in ANCOVA. Academic Ethics: Plagiarism, exposure on anti-plagiarism tools.

Unit No: IV	Technical Writing and IPR	10 Hours

Academic writing, sources of information, assessment of quality of journals and articles, writing scientific report, structure and component of research report, types of report – technical reports and thesis, SCOPUS Index, citations, search engines beyond google, impact factor, H-Index. IPR: What is IPR? The importance of patents, types of IPR,
and process of patent.

Unit No: V	Outcome of Research and Research Presentation	10 Hours

Relevance, interest, available data, choice of data, Analysis of data, Generalization and interpretation of analysis, Preparation of the Report on conclusions reached, testing validity of research outcomes, Suggestions and recommendations, identifying future scope.

Research presentation: Introduction, Standard terms, Standard research methods and experimental techniques, Paper title and keywords, Writing an abstract, Paper presentation and review, Conference presentations, Poster presentations, IPR, Copyright, Patents.

Case Study: Intellectual Property India- services, InPASS - Indian Patent Advanced Search System, US patent, IEEE / ACM Paper templates.

Learning Resources

1. Text Books

[T1]. Kothari, C.R., Research Methodology: Methods and Techniques. New Age International

[T2]. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., An introduction to Research Methodology, RBSA Publishers

[T3]. Suresh Sinha, Anil K Dhiman, Research Methodology, ESS Publications,Volumes 2.

[T4]. Day R.A., How to Write and Publish a Scientific Paper, Cambridge University Press

[T5]. Wadehra, B.L. Law relating to patents, Trademarks, copyright designs and geographical indications. Universal Law Publishing

[T6]. Shail Jain, R.K. Jain, Patents: Procedures and Practices, Universal Law Publishing Co., New Delhi, 2011.

[T7]. Dawson, Catherine, 2002, Practical Research Methods, New Delhi, UBS Publishers' Distributors.

2. Reference Books

[R1]. Louis Cohen, Lawrence Manion and Keith Morrison, Research Methods in Education, 7th Edition, Cambridge University Press, ISBN – 978-0415-58336-7

[R2]. Anthony, M., Graziano, A.M. and Raulin, M.L., Research Methods: A Process of Inquiry, Allyn and Bacon

[R3]. Ranjit Kumar, Research Methodology: A Step by Step Guide for Beginners, 2nd Edition, APH Publishing Corporation.

[R4]. Leedy, P.D. and Ormrod, J.E., Practical Research: Planning and Design, Prentice Hall
[R5]. Fink, A., Conducting Research Literature Reviews: From the Internet to Paper. Sage Publications
[R6]. Satarkar, S.V., Intellectual Property Rights and Copy Right. ESS Publications.
[R7]. Royston M. Roberts, Serendipity: Accidental Discoveries in Science, Wiley Publication, 1989

3. Links to online SWAYAM/NPTEL Courses

1. Research Methodology - Course
2. Research Methodology - Course

https://www.youtube.com/playlist?list=PLm-zueI9b64QGMcfn5Ckv_8W5Z1d3vMBY

Practical Assignments / Mini Project Problem Statements

Sr.	Title	Objectives
1	Problem Identification Exercise	Identify and clearly define a real-world research problem in your engineering discipline.
2	Literature Review Report	Conduct a detailed literature survey (minimum 30 research papers) and summarize gaps in existing research.
3	Research Proposal Drafting	Prepare a structured research proposal including problem statement, objectives, scope, and methodology.
4	Hypothesis Formulation	Develop testable hypotheses based on selected research problems.
5	Design of Experiment	Design a detailed experimental plan or simulation for validating hypotheses.
6	Sampling Techniques	Select and justify a sampling method for data collection in your project.
7	Data Collection Tools Development	Design a survey questionnaire or sensor-based data collection method.
8	Statistical Data Analysis	Perform statistical analysis (ANOVA, regression, t-tests) on sample data.
9	Research Paper Writing	Draft a full research paper based on hypothetical or preliminary data.
10	Research Ethics and Plagiarism Check	Analyze ethical aspects and conduct a plagiarism check for your paper.

Mini Project statement list for Research Methodology (ANYONE)

Sr.	Project Title	Description/Deliverable
1	AI-based Systematic Literature Review Tool	Build a tool that automates screening and organizing research papers.
2	Comparison of Research Methodologies	Compare qualitative vs. quantitative methods through case studies.
3	Development of a Research Gap Identification Model	Create an algorithm that detects research gaps from published articles.
4	Design of a Predictive Analytics Model	Design a model that predicts the future trend of research in a selected field.
5	Big Data Analysis for Research Trends	Analyze publication data from Scopus/IEEE/Google Scholar to identify top emerging topics.
6	AI-based Systematic Literature Review Tool	Build a tool that automates screening and organizing research papers.

Savitribai Phule Pune University
Board: Electrical Engineering
ME (ELECTRICAL ENGINEERING) (2025 Pattern)

Course Code: OJT-602-COS	**Course Name:** On Job Training/ Internship	
Teaching Scheme	**Credits**	**Examination Scheme**
Practical : 10 Hours/Week	05	TW : 100 Marks

Prerequisite: Core Technical Knowledge, Software & Tools Proficiency, Understanding of Industry Practices, Prior Academic Work

The objectives are,

1. To put theory into practice. And expand thinking and broaden the knowledge and skills acquired through course work in the field.
2. To relate to, interact with, and learn from current professionals in the field.
3. To understand and adhere to professional standards in the field.
4. To gain insight into professional communication including meetings, memos, reading, writing, public speaking, research, client interaction, input of ideas, and confidentiality.
5. To develop the initiative and motivation to be a self-starter and work independently.

Course Outcomes:

At the end of course, the student will be able to

1. **CO1**: Gain practical experience within the industry in which the internship is done.
2. **CO2:** Acquire knowledge of the industry in which the internship is done.
3. **CO3:** Apply knowledge and skills learned to classroom work.
4. **CO4**: Develop and refine oral and written communication skills.
5. **CO5:** Acquire knowledge of administration, marketing, finance and economics.

Course description

1. Internship/On Job Training provides students with the opportunity of hands-on experience that in- clues personal training, time and stress management, interactive skills, presentations, budgeting, marketing, liability and risk management, paperwork, equipment ordering, maintenance, responding to emergencies etc.
2. An internship is the phase of time for students when they are trained for their skills, they are good at, and it gives them a chance to apply their knowledge practically in industries
3. The internship can be carried out in any industry/R&D Organization/Research Institute/Institute of national repute/R&D Centre of Parent Institute.
4. The Department/college shall nominate a faculty to facilitate, guide and supervise students under internship.

Guidelines

- **Purpose:**

  Internships are designed to bridge the gap between academic learning and industry practice. They aim to provide hands-on experience, expose students to the industrial environment, develop technical and soft skills (communication, teamwork, problem-solving), and help in career exploration.

- **Internship Duration and Academic Credentials**
  - Students can take internship work in the form of Online/Offline mode from any of the Industry / Government Organization Internship Programs approved by SPPU/AICTE/UGC portals
  - An intern is expected to spend 10 - 12 hours per week on Internship, Training will result in about 160-170 hours of total internship duration.
  - The minimum requirement regarding Internship duration should not be below 8 weeks

- **Type of Internship**
  - Industry/Government Organization Internship: Working directly with a company or government body.
  - Research Internship: Focused on research projects, often in collaboration with academic institutions or R&D labs.
  - Innovation/Entrepreneurship: Working on developing new products, processes, or even starting a venture.
  - Social Internship: Engaging in community-based projects.
- **Assessment Details (TW and Practical)**
  - Term work for 100 marks
  - A daily log submitted by the student and a work log signed by the office HoDs where the student has interned will be considered towards the TW marking.
- **Indicative list of areas for OJT**
  - Trade and Agriculture
  - Economy & Banking Financial Services and Insurance
  - Logistics, Automotive & Capital Goods
  - Fast Moving Consumer Goods & Retail
  - Information Technology/Information Technology Enabled Services & Electronics
  - Handcraft, Art, Design & Music
  - Healthcare & Life Science
  - Sports, Wellness and Physical Education
  - Tourism & Hospitality
  - Digitization & Emerging Technologies (Internet of Things / Artificial Intelligence / Machine
  - Learning / Deep Learning / Augmented Reality / Virtual Reality etc.)
  - Humanitarian, Public Policy and Legal Services
  - Communication
  - Education
  - Sustainable Development & Environment
  - Commerce, Medium and Small-Scale Industries
- **Faculty Supervision**

  Students are usually assigned an internal faculty guide/mentor who supervises their internship activities. This faculty member acts as a teacher, mentor, and critic, and ensures the internship aligns with academic goals. External Supervision: In many cases, an external expert from the host organization also guides the student.
- **Documentation and Reporting**
  - Joining Report: To be submitted within a specified time frame (e.g., one week from joining).
  - Daily/Periodical Diary: Students are often required to maintain a daily or weekly record of their observations, work, and learning.
  - Internship Report: A comprehensive report detailing the work done, learning outcomes, and achievements during the internship. This report needs to be duly signed by the company official and faculty mentor.
  - Completion Certificate: Issued by the host organization upon successful completion.
- **Evaluation**
  - Evaluation is typically done by the institute, often within a short period after the internship ends
  - It may involve presentations, viva-voce examinations, and assessment of the internship report and daily diary.
  - Performance-based feedback from the industry mentor is usually a key component.

Savitribai Phule Pune University
Board: Electrical Engineering
ME (ELECTRICAL ENGINEERING) (2025 Pattern)

Course Code: SEM-603-COS		**Course Name: Technical Seminar-II**
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 00 Hrs	--	TW : 25 Marks
Practical : 08 Hrs	04	OR : 25 Marks

Course Description:
The seminar aims to enhance students' research, presentation, and critical thinking skills, preparing them for advanced academic pursuits and professional careers.

The objectives are,

1. Deepen Technical Knowledge: To enable students to explore a specialized topic within Electrical Engineering beyond the regular curriculum, fostering in-depth understanding.
2. Develop Research Skills: To provide practical experience in identifying, acquiring, evaluating, and synthesizing information from various technical sources (research papers, standards, technical reports).
3. Enhance Communication Skills: To cultivate effective oral and visual presentation skills, enabling students to articulate complex technical concepts clearly and concisely to a knowledgeable audience.
4. Foster Critical Thinking: To encourage students to critically analyze existing research, identify challenges, propose solutions, and engage in constructive discussions.
5. Promote Independent Learning: To encourage self-directed learning and the ability to stay updated with emerging technologies and research trends.
6. Prepare for Thesis/Dissertation: To serve as a foundational step for the Master's thesis/dissertation, allowing students to explore potential research areas.

Course Outcomes: At the end of the course, the student will be able to

1. Formulate the goals and objectives of scientific research.
2. Search, evaluate and analyze information about the achievements of science and technology in the target area and beyond.
3. Interpret data from different fields of science and technology.
4. Build the logic of reasoning and statements.
5. Create, design and edit text documents in accordance with the requirements of the organization or publisher.

Course description

- **Responsibility of the students**
  - The Seminar should be carried out individually by each student.
  - A student should identify the area or topics in recent trends and developments in consultation with the guide
  - A student should report to his/her respective guide regularly (at least once a week) and report the progress of the seminar work.
  - A student should follow the timelines and deadlines and inform the supervisor in case of any difficulty/delay.
  - Students should maintain the record of all the meetings, remarks given by guide/reviewers and progress of the work in the project diary. The project diary must be presented during each review presentation to the reviewers.
  - A student should conduct the research ethically, adhere to the academic integrity standards, and cite

sources whenever using any existing results

- A student should Incorporate constructive feedback to improve the quality and rigor of the research
- For final examination, students should complete the Seminar Report in all aspects including formatting and citation.
- Each student should prepare the report, get it approved by his/her guide and submit the duly signed copy within the deadline.
- A student should invest time and effort in preparing seminar presentations and the oral defense of the seminar

- **Topic Selection**
  - **Relevance:** Topics must be directly related to Electrical Engineering, encompassing cur- rent research trends, emerging technologies, advanced concepts, or interdisciplinary applications
  - **Scope:** The topic should be sufficiently focused to allow for in-depth exploration within the seminar timeframe, yet broad enough to demonstrate a comprehensive understanding. Avoid overly narrow or excessively broad topics.
  - **Novelty (Desired):** While not strictly a research paper, students are encouraged to explore topics that have recent advancements, open problems, or areas where their unique insights can be presented. Avoid merely summarizing introductory textbook material.
  - **Guide / Supervisor Approval**: Each student must select a seminar topic in consultation with and obtain approval from an assigned faculty supervisor. The supervisor will guide the student in refining the topic and identifying relevant resources.
  - **Examples of Broad Areas:** Optimization Techniques in Control System, Automation in Manufacturing, System Identification and Adaptive Control, Industrial Automation and Control, Automation and Robotics, Modelling of Dynamic System, Control of Power Electronics Circuits, Digital Signal Processing and its Applications, Modern Control Systems
- **Seminar Structure and Deliverables:**

  The technical seminar typically involves the following stages and deliverables
  - Topic Proposal (2-3 weeks after topic approval):
  - A concise document (1-2 pages) outlining:
  - Proposed Seminar Title
  - Brief Description/Abstract of the Topic
  - Motivation and Relevance to Electrical Engineering
  - Preliminary List of Key References (at least 5-7 reputable sources)
  - Tentative Scope and Outline of the Presentation
  - Submission: To the faculty supervisor for approval.
  - Literature Review and Research (Ongoing): Sources: Students must primarily rely on peer-reviewed academic sources (IEEE Xplore, ACM Digital Library, SpringerLink, arXiv, Google Scholar), reputable conference proceedings, and established industry standards. Wikipedia and unverified blogs are generally not acceptable as primary sources.
  - Critical Analysis: Beyond mere summarization, students are expected to critically analyze the literature, identifying different approaches, their advantages/disadvantages, open issues, and potential future directions.
  - Note-Taking & Organization: Maintain systematic notes and organize research material effectively.
- **Seminar Report**
  - A written report (typically 15-25 pages, excluding references and appendices) detailing the seminar content.

- Format: Follow a professional academic paper format (e.g., IEEE transaction style).
- **Sections**
  - **Abstract:** A concise summary of the seminar topic and key findings.
  - **Introduction**: Background, motivation, problem statement (if applicable), and outline of the report.
  - **Literature Review/Background**: Detailed discussion of relevant concepts, theories, and existing work.
  - **Core Content:** In-depth exploration of the chosen topic, presenting different methodologies, architectures, algorithms, or challenges as relevant.
  - **Analysis/Discussion**: Critical evaluation of the presented material, comparing different approaches, discussing implications, and identifying gaps.
  - **Future Trends/Conclusion:** Summarization of key takeaways, potential future directions, and concluding remarks.
  - **References:** A comprehensive list of all cited sources properly formatted.
  - Appendices (Optional): Supplementary material if necessary.

- **Oral/ Presentation**
  - Duration: Typically, 25-30 minutes for presentation, followed by 10-15 minutes for Q&A. (Specific timings will be announced)
  - Audience: Faculty members, peers, and potentially other interested individuals.
  - Content: The presentation should effectively convey the key aspects of the seminar topic.
  - It should not simply be a reading of the report.
  - Visual Aids: High-quality presentation slides (e.g., PowerPoint, Google Slides, LaTeX Beamer) are mandatory. Slides should be clear, concise, visually appealing, and support the oral delivery. Avoid excessive text on slides.
  - Delivery: Clear articulation, confident posture, good eye contact, and appropriate pace.
  - Practice the presentation thoroughly.
  - Q&A Session: Be prepared to answer questions from the audience on all aspects of the seminar topic. Demonstrate a strong understanding and ability to defend your perspectives.

- **Evaluation Criteria:** The technical seminar will be evaluated based on the following criteria:
  - Topic Selection and Scope (10%): Relevance, timeliness, and appropriate depth of the chosen topic. Clarity and focus of the topic proposal.
  - Literature Review and Research (25%): Breadth and depth of literature surveyed. Quality and credibility of sources used. Critical analysis and synthesis of information.
  - Seminar Report/Paper (30%): Clarity, organization, and logical flow of content. Technical accuracy and depth of discussion. Adherence to academic writing standards (grammar, spelling, formatting, referencing). Originality in synthesis and critical insights. Absence of plagiarism.
  - Oral Presentation (35%): Content: Clarity, completeness, and accuracy of the presented material. Organization: Logical flow, effective use of time. Visual Aids: Quality, clarity, and effectiveness of slides. Delivery: Confidence, clarity of speech, enthusiasm, engagement with the audience. Q&A: Ability to answer questions accurately, comprehensively, and confidently.

Learning Resources
Textbooks
[T1]. "Engineering Communication" by Charles W. Knisely & Karin I. Knisely [T2]. "Technical Communication: Principles and Practice" by Meenakshi Raman & Sangeeta Sharma [T3]. "The Craft of Scientific Presentations" by Michael Alley
Swayam/ NPTEL Courses
[1]. https://nptel.ac.in/courses/109/106/109106180/ [2]. https://www.udemy.com/course/technical-writing/ [3]. https://www.edx.org/course/writing-in-the-sciences

Savitribai Phule Pune University
Board: Electrical Engineering
ME (ELECTRICAL ENGINEERING) (2025 Pattern)

Course Code: RPR-604-COS		**Course Name:** Research Project - I
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 00 Hrs	--	TW : 25 Marks
Practical : 18 Hrs	09	OR : 25 Marks

Course Description:

The master's degree culminates in a research project of the student's own design. This research project is documented by a final research report or dissertation. The student's work is guided by an academic supervisor. Students are expected to choose real-world contemporary problems and apply the engineering principles learned, to solve the problem through building prototypes or simulations or writing codes or establishing processes/synthesis/correlations etc. Students are expected to construct a research project that includes original research, deliberate and well considered methodological choices, and shows relevance to significant conversations
within the discipline. The dissertation should represent the very best research and analysis a student can produce.

Course Objectives:

1. Demonstrate an ability to plan a research project, such as is required in a research proposal prior to the launch of their work
2. Demonstrate an ability to comply with ethical, safety, and documentation processes appropriate to their project
3. Demonstrate expert knowledge in the subject of their research project, such as through an integrated literature survey
4. Demonstrate expert knowledge in the research methods appropriate to generating reliable data for their research questions
5. Demonstrate the ability to manage projects and to make constructive use of expertise associated with their project, while working as an independent learner
6. Demonstrate an ability to relate their original data to existing literature, or to create an novel synthesis of existing materials
7. Demonstrate an ability to assemble their findings into a substantial piece of writing that presents a clear thesis and a cohesive, evidence-based argument
8. Demonstrate an ability to balance description, analysis, and synthesis within their project report
9. Demonstrate an ability to reflect on the strengths and weaknesses of their research and methodology, with constructive advice on how they might improve their efforts in future work

Course Outcomes: At the end of the course, the student will be able to

1. CO1: Demonstrate how to search the existing literature to gather information about a specific problem or domain.
2. CO2: Identify state-of-the-art technologies and research in the chosen domain, and high- light open problems that are relevant to societal or industrial needs.
3. CO3: Evaluate various solution techniques to determine the most feasible solution within given constraints for the chosen dissertation problem.
4. CO4: Apply software engineering principles related to requirements gathering and design to produce relevant documentation.

5. CO5: Write a dissertation report that details the research problem, objectives, literature review, and solution architecture.

Guidelines

1. **General Guidelines:**
   a. The dissertation is a year-long project, conducted and evaluated in two phases. It can be carried out either in-house or within an industry as assigned by the department. The project topic and internal advisor (a faculty member from the department) are determined at the beginning of Phase I.

   b. Students are expected to complete the following activities in Phase-I:

   (a) Literature survey

   (b) Problem Definition

   (c) Motivation for study and Objectives

   (d) Preliminary design / feasibility / modular approaches

   (e) Design of the research project

2. **Research Project Stage-I, Phases**

Phase 1: Informal conversations

Students are strongly encouraged to discuss possible research project ideas with the internal guide, fellow students, and other research professionals. All research projects begin with open-ended conversations and scoping exercises. These should be non-committal.

Phase 2: Identify topic

The first formal step in the module involves identifying a preliminary project title and writing an abstract of no more than 200 words. This requires submitting a completed registration form. Writing an abstract for a research proposal or for completed research work is an important transferable skill. Students who do not submit a completed registration form will be assigned a project. The project title is understood to be provisional. Supervisors will be assigned to students after the project title/ abstract forms have been submitted. Supervision: A supervisor is required. The main responsibilities of the supervisor are to assist the student with project management and to advise the student on criteria for assessment. You can expect your supervisor to read and comment on a full draft of your research proposal and of your project.

It is a good idea to discuss a timeline for your project with your supervisor, and to establish a definite timetable.

Some key points in our advice to students on compliance:

1. Allow at least two weeks between submitting an ethics application and the date of your first data collection,
2. Your supervisor must approve (and sign!) your ethics application before you submit it at departmental level
3. After your protocols have been approved, append a copy of your ethical approval certificate to the dissertation and project proposal.

Phase 3: Project proposal

The proposal should reflect a student's best effort. At the same time, we recognize research often raises new questions. Some redefinitions of topics and titles are common later in the research process. Students should keep their supervisors up to date on these developments, and they can expect a reasonable amount of adaptation.

Phase 4: Term-1 research

Students are expected to commit substantial time during the term to their research project. The principal form of academic input for the research project normally comes through discussions with the designated

supervisor. The majority of these meetings should be face-to-face, either in person or via video- or audio-conferencing technology.

Students are expected to respect these periods of absence and plan their needs accordingly. One distinction is crucial.

(1) when staff are on leave, they are off work (i.e., not expected to maintain contact with their supervisees or to undertake their duties); however,

(2) when staff are working remotely, they are at work (i.e., expected to maintain contact and to be available for normal duties).

A student's supervisor is not the only person who may advise on projects and writing. Others include peers and subject experts.

Phase 5: Submit Project report

The project report with the specific due date must be submitted to the Department.

Additional Information

- **Research notebook**: Students are strongly advised to maintain a research notebook, either digital or paper, and to keep this up to date. A research notebook can prove useful should examiners query research methods, research integrity, or research process.
- **Preventing data loss**: Protect yourself against loss of research material and writing by maintaining a system

  for secure, redundant, up-to-date back-up of research material and writing. Loss cannot be accepted as a reason for failing to meet a deadline. A copy of written notebooks can be stored by supervisors for the duration of the project. Loss of project materials through accidents and theft have occurred in the past; these have had devastating effects on the un- prepared. All students are warned to create redundancies to protect their project from similar calamities.
- **Extensions:** This is a long-term research project, and time management is a learning objective. Short-term extensions normally are not considered. Applications for extension must be made through the processes described in the STS Student Handbook. Personal Tutors are the first point of contact on extension requests.
- **Word counts:** Words counted towards the total word count include the main body of the report and supporting footnotes or endnotes. The word count does not include bibliography, front matter (title page, keywords, abstract, table of contents, acknowledgments), appendix material, supplemental data packages, table and figure legends, or documentation of ethics protocols or approvals. Otherwise, University standard policy on word counts will apply.
- **Re-using coursework from other modules:** Text and ideas in the research proposal may reappear in the dissertation if significantly developed or further elaborated; however, Universities policy on self-plagiarism prevents the same work receiving credit twice. This means rote duplication is not allowed.
- **Citation format:** The style must be clear, explicit, and meaningful. In every instance, it must allow an examiner to locate efficiently and specifically material referred to. As a recommendation, students should use a style frequently used in the literature relevant to their research project. Most journals have style guides in their notes to contributors. Students should discuss options with their supervisors, and they should keep in mind that efficient citation is one element in the criteria for assessment.

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SEMESTER-IV

Master of Engineering (2025 Pattern)

M.E. Electrical (Control Systems)

Savitribai Phule Pune University Board: Electrical Engineering ME (ELECTRICAL ENGINEERING) (2025 Pattern)			
Course Code: SEM-651-COS		**Course Name: Technical Seminar-III**	
Teaching Scheme	**Credits**	**Examination Scheme**	
Theory : 00 Hrs	--	TW	: 50 Marks
Practical : 08 Hrs	04	OR	: 50 Marks

Course Description:

The seminar aims to enhance students' research, presentation, and critical thinking skills, preparing them for advanced academic pursuits and professional careers.

The objectives are,

1. Deepen Technical Knowledge: To enable students to explore a specialized topic within Electrical Engineering beyond the regular curriculum, fostering in-depth understanding.
2. Develop Research Skills: To provide practical experience in identifying, acquiring, evaluating, and synthesizing information from various technical sources (research papers, standards, technical reports).
3. Enhance Communication Skills: To cultivate effective oral and visual presentation skills, enabling students to articulate complex technical concepts clearly and concisely to a knowledgeable audience.
4. Foster Critical Thinking: To encourage students to critically analyze existing research, identify challenges, propose solutions, and engage in constructive discussions.
5. Promote Independent Learning: To encourage self-directed learning and the ability to stay updated with emerging technologies and research trends.
6. Prepare for Thesis/Dissertation: To serve as a foundational step for the Master's thesis/dissertation, allowing students to explore potential research areas.

Course Outcomes: At the end of the course, the student will be able to

1. Formulate the goals and objectives of scientific research.
2. Search, evaluate and analyze information about the achievements of science and technology in the target area and beyond.
3. Interpret data from different fields of science and technology.
4. Build the logic of reasoning and statements.
5. Create, design and edit text documents in accordance with the requirements of the organization or publisher.

Course description

- **Responsibility of the students**
  - The Seminar should be carried out individually by each student.
  - A student should identify the area or topics in recent trends and developments in consultation with the guide
  - A student should report to his/her respective guide regularly (at least once a week) and report the progress of the seminar work.
  - A student should follow the timelines and deadlines and inform the supervisor in case of any difficulty/delay.
  - Students should maintain the record of all the meetings, remarks given by guide/reviewers and progress of the work in the project diary. The project diary must be presented during each review presentation to the reviewers.

- A student should conduct the research ethically, adhere to the academic integrity standards, and cite sources whenever using any existing results
- A student should Incorporate constructive feedback to improve the quality and rigor of the research
- For final examination, students should complete the Seminar Report in all aspects including formatting and citation.
- Each student should prepare the report, get it approved by his/her guide and submit the duly signed copy within the deadline.
- A student should invest time and effort in preparing seminar presentations and the oral defense of the seminar

- **Topic Selection**
  - **Relevance:** Topics must be directly related to Electrical Engineering, encompassing cur- rent research trends, emerging technologies, advanced concepts, or interdisciplinary applications
  - **Scope:** The topic should be sufficiently focused to allow for in-depth exploration within the seminar timeframe, yet broad enough to demonstrate a comprehensive understanding. Avoid overly narrow or excessively broad topics.
  - **Novelty (Desired):** While not strictly a research paper, students are encouraged to explore topics that have recent advancements, open problems, or areas where their unique insights can be presented. Avoid merely summarizing introductory textbook material.
  - **Guide / Supervisor Approval**: Each student must select a seminar topic in consultation with and obtain approval from an assigned faculty supervisor. The supervisor will guide the student in refining the topic and identifying relevant resources.
  - **Examples of Broad Areas:** Optimization Techniques in Control System, Automation in Manufacturing, System Identification and Adaptive Control, Industrial Automation and Control, Automation and Robotics, Modelling of Dynamic System, Control of Power Electronics Circuits, Digital Signal Processing and its Applications, Modern Control Systems
- **Seminar Structure and Deliverables:**

  The technical seminar typically involves the following stages and deliverables
  - Topic Proposal (2-3 weeks after topic approval):
  - A concise document (1-2 pages) outlining:
  - Proposed Seminar Title
  - Brief Description/Abstract of the Topic
  - Motivation and Relevance to Electrical Engineering
  - Preliminary List of Key References (at least 5-7 reputable sources)
  - Tentative Scope and Outline of the Presentation
  - Submission: To the faculty supervisor for approval.
  - Literature Review and Research (Ongoing): Sources: Students must primarily rely on peer-reviewed academic sources (IEEE Xplore, ACM Digital Library, SpringerLink, arXiv, Google Scholar), reputable conference proceedings, and established industry standards. Wikipedia and unverified blogs are generally not acceptable as primary sources.
  - Critical Analysis: Beyond mere summarization, students are expected to critically analyze the literature, identifying different approaches, their advantages/disadvantages, open issues, and potential future directions.
  - Note-Taking & Organization: Maintain systematic notes and organize research material effectively.

  - **Seminar Report/ Paper (Due 2-3 weeks before presentation)**

- A written report (typically 15-25 pages, excluding references and appendices) detailing the seminar content.
- Format: Follow a professional academic paper format (e.g., IEEE transaction style).
- **Sections**
  - **Abstract:** A concise summary of the seminar topic and key findings.
  - **Introduction**: Background, motivation, problem statement (if applicable), and outline of the report.
  - **Literature Review/Background**: Detailed discussion of relevant concepts, theories, and existing work.
  - **Core Content:** In-depth exploration of the chosen topic, presenting different methodologies, architectures, algorithms, or challenges as relevant.
  - **Analysis/Discussion**: Critical evaluation of the presented material, comparing different approaches, discussing implications, and identifying gaps.
  - **Future Trends/Conclusion:** Summarization of key takeaways, potential future directions, and concluding remarks.
  - **References:** A comprehensive list of all cited sources properly formatted.
  - Appendices (Optional): Supplementary material if necessary.

- **Oral/ Presentation**
  - Duration: Typically, 25-30 minutes for presentation, followed by 10-15 minutes for Q&A. (Specific timings will be announced)
  - Audience: Faculty members, peers, and potentially other interested individuals.
  - Content: The presentation should effectively convey the key aspects of the seminar topic.
  - It should not simply be a reading of the report.
  - Visual Aids: High-quality presentation slides (e.g., PowerPoint, Google Slides, LaTeX Beamer) are mandatory. Slides should be clear, concise, visually appealing, and support the oral delivery. Avoid excessive text on slides.
  - Delivery: Clear articulation, confident posture, good eye contact, and appropriate pace.
  - Practice the presentation thoroughly.
  - Q&A Session: Be prepared to answer questions from the audience on all aspects of the seminar topic. Demonstrate a strong understanding and ability to defend your perspectives.

- **Evaluation Criteria:** The technical seminar will be evaluated based on the following criteria:
  - Topic Selection and Scope (10%): Relevance, timeliness, and appropriate depth of the chosen topic. Clarity and focus of the topic proposal.
  - Literature Review and Research (25%): Breadth and depth of literature surveyed. Quality and credibility of sources used. Critical analysis and synthesis of information.
  - Seminar Report/Paper (30%): Clarity, organization, and logical flow of content. Technical accuracy and depth of discussion. Adherence to academic writing standards (grammar, spelling, formatting, referencing). Originality in synthesis and critical insights. Absence of plagiarism.
  - Oral Presentation (35%): Content: Clarity, completeness, and accuracy of the presented material. Organization: Logical flow, effective use of time. Visual Aids: Quality, clarity, and effectiveness of slides. Delivery: Confidence, clarity of speech, enthusiasm, engagement with the audience. Q&A: Ability to answer questions accurately, comprehensively, and confidently.

Learning Resources
Textbooks
[T1]. "Engineering Communication" by Charles W. Knisely & Karin I. Knisely [T2]. "Technical Communication: Principles and Practice" by Meenakshi Raman & Sangeeta Sharma [T3]. "The Craft of Scientific Presentations" by Michael Alley
Swayam/ NPTEL Courses
[1]. https://nptel.ac.in/courses/109/106/109106180/ [2]. https://www.udemy.com/course/technical-writing/ [3]. https://www.edx.org/course/writing-in-the-sciences

Savitribai Phule Pune University
Board: Electrical Engineering
ME (ELECTRICAL ENGINEERING) (2025 Pattern)

Course Code: RPR-652-COS		**Course Name:** Research Project - II
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 00 Hrs	--	TW : 150 Marks
Practical : 36 Hrs	18	OR/Presentation : 50 Marks

Course Description:

The master's degree culminates in a research project of the student's own design. This research project is documented by a final research report or dissertation. The student's work is guided by an academic supervisor. Students are expected to choose real-world contemporary problems and apply the engineering principles learned, to solve the problem through building prototypes or simulations or writing codes or establishing processes/synthesis/correlations etc. Students are expected to construct a research project that includes original research, deliberate and well considered methodological choices, and shows relevance to significant conversations
within the discipline. The dissertation should represent the very best research and analysis a student can produce.

Course Objectives:

1. Demonstrate an ability to plan a research project, such as is required in a research proposal prior to the launch of their work
2. Ability to manage projects and to make constructive use of expertise associated with their project, while working as an independent learner
3. Ability to relate their original data to existing literature, or to create a novel synthesis of existing materials
4. Identify and formulate a problem of research interest in the chosen area of computing.

Course Outcomes: At the end of the course, the student will be able to

1. **CO1: Undertake** independent research that makes an original contribution to knowledge, or produces a novel synthesis of existing materials relevant to significant conversations in the discipline
2. **CO2: Plan** their project in advance, using a proposal to describe their undertaking, describe how it will be managed, and reflect upon its value
3. **CO3: Relate** their original research to existing literature on the subject and relate their work to general themes in their relevant scholarly literature
4. **CO4: Assemble** their rationale, methods, findings, and analysis into a substantial piece of writing that presents a clear thesis and a cohesive evidence-based argument or analysis
5. **CO5: Reflect** on the strengths and weaknesses of their research and methodology, understanding how they might improve their efforts in future work

Guidelines

1. General Guidelines:

- The student shall consolidate and complete the remaining part of the research work started in Semester III. This will consist of Selection of Technology, Installations, implementations, testing, Results, measuring performance, discussions using data tables per parameter considered for the improvement with existing/known algorithms/systems, comparative anal- ysis, validation of results and conclusions.
- The student shall prepare the duly certified final report of dissertation in standard format for satisfactory completion of the work by the concerned guide and head of the Department/Institute.
- The students are expected to validate their study undertaken by publishing it on standard platforms.

The investigations and findings need to be validated appropriately at standard platforms like conference and/or peer reviewed journal.

- The student has to exhibit continuous progress through regular reporting and presentations and proper documentation of the frequency of the activities in the sole discretion of the PG coordination/Head of the department. The continuous assessment of the progress needs to be documented unambiguously.
- Supervisor Interaction: Minimum one meeting per week.
- Logbook: Maintain a record of work progress and supervisor comments.
- Ethics: No plagiarism, false results, or unethical practices allowed.
- Backup: Keep source code, datasets, and reports backed up securely.
- Submission Format: Soft copy (PDF) + Hard copy as per institute norms.

2. Key Components

Implementation

- Students Complete development/simulation/testing of the system or model.
- Ensure correctness, efficiency, and validation of results.

Results & Analysis

- Include experimental setup, datasets used, performance metrics.
- Graphs, tables, and comparison with existing techniques.
- Highlight key findings and their significance.

Conclusion and Future Work

- Summarize outcomes, contributions, and applications.
- Suggest extensions or improvements for future research.

Paper Publication

- At least one paper (optional/encouraged) in peer-reviewed conference/journal.
- Attach publication/proof as appendix (if available).

Final Report Format

- Revised version of Stage 1 report with added implementation, results, and conclusion chapters.
- Maintain academic writing standards and include all necessary references.

Plagiarism Report

- The final version must again be checked and should not exceed 15% similarity.

Evaluation Parameters

- Completeness and quality of implementation
- Analysis and originality of results
- Quality of documentation and adherence to format
- Viv-voce performance and clarity of understanding
- Contribution to knowledge or innovation

Savitribai Phule Pune University, Pune

Maharashtra, India

सावित्रीबाई फुले पुणे विद्यापीठ

Task Force for Curriculum Design and Development

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Reviewed by:

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