ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY & SCIENCES
DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

R-23 COURSE STRUCTURE

M. Tech. (Control Systems Engineering)

SCHEME OF INSTRUCTION AND EXAMINATION UNDER AUTONOMOUS SYSTEM

I Year – Semester – I

Course Code	Title of the Course	Category	Periods per week			Max. marks		Total Marks	Credits
			L	T	P	Sess.	End Exam		
23ECS111	Systems & Control	PC	3	0	0	40	60	100	3
23ECS112	Advanced Drives & Control	PC	3	0	0	40	60	100	3
23ECS113	Professional Elective-I	PE	3	0	0	40	60	100	3
23ECS114	Professional Elective-II	PE	3	0	0	40	60	100	3
23ECS115	Research Methodology & IPR	MC	3	0	0	100	-	100	3
23ECS116	Control Systems Lab	PC	0	0	4	50	50	50	2
23ECS117	Seminar-I	SC	0	0	2	50	-	50	1
23ECS118	Constitution of India	Audit	2	0	0	50	-	50	0
Total			**17**	**0**	**6**	**410**	**290**	**700**	**18**

PROFESSIONAL ELECTIVE -I:	PROFESSIONAL ELECTIVE -II:
(a) Large Scale Systems	(a) Robotics
(b) Modern Control Systems	(b) Digital Control Systems
(c) Control Systems Components	(c) Optimization Techniques

I Year – Semester – II

Course Code	Title of the Course	Category	Periods per week			Max. marks		Total Marks	Credits
			L	T	P	Sess.	End Exam		
23ECS121	Advanced Control Systems and Design	PC	3	0	0	40	60	100	3
23ECS122	Nonlinear Control Systems	PC	3	0	0	40	60	100	3
23ECS123	Optimal & Adaptive Control	PC	3	0	0	40	60	100	3
23ECS124	Professional Elective-III	PE	3	0	0	40	60	100	3
23ECS125	Professional Elective-IV	PE	3	0	0	40	60	100	3
23ECS126	Control Systems Simulation Lab	PC	0	0	4	50	50	100	2
23ECS127	Seminar-II	SC	0	0	2	50	-	50	1
23ECS128	English for Research Paper Writing	Audit	2	0	0	50	—	50	0
Total			**17**	**0**	**6**	**350**	**350**	**700**	**18**

PROFESSIONAL ELECTIVE -III:

(a) Sliding Mode Control

(b) Process Control & Automations

(c) Hybrid Electrical Vehicles

PROFESSIONAL ELECTIVE -IV:

(a) Intelligent Systems & Control

(b) Modeling and Control of Power Converters

(c) Stochastic Estimation and Control

II Year – I Semester

Course Code	Title of the Course	Category	Periods per week			Total	Max. marks		Total Marks	Credits
			L	T	P		Sess.	End Exam		
23ECS211	MOOC-I	OE	0	0	0	0	100	—	100	3
23ECS212	MOOC-II	OE	0	0	0	0	100	—	100	3
23ECS213	Project Thesis-I	PR	0	0	20	20	100	—	100	10
Total			**0**	**0**	**20**	**20**	**300**	**—**	**300**	**16**

II Year – II Semester

Course Code	Title of the course	Category	Periods per week			Total	Max. Marks		Total Marks	Credits
			L	T	P		Sess.	End Exam		
23ECS221	Project Thesis-I	PR	0	0	32	32	100	100	200	16
Total			**0**	**0**	**32**	**32**	**100**	**100**	**200**	**16**

The prerequisite for submission of the M Tech thesis is that one should communicate his/her work to any referred journal or Publication in a conference/journal.

SYLLABUS FOR M.Tech. (CONTROL SYSTEM)

SEMESTER – I

23CS 111: Systems & Control

Credits : 3 Lectures per week : 3

Univ. Exam. Marks : 60 Sessional Marks : 40

Total Marks : 100

CO 1	**Apply** signal flow graph and block diagram reduction techniques to **Develop** Transfer function for Linear time invariant systems.
CO 2	**Apply** the relationship between the variables of electrical and mechanical systems to **Develop** mathematical models of electrical and mechanical systems.
CO 3	**Analyze** the performance of 1^{st} and 2^{nd} order Linear time invariant systems with and without feedback control to **Determine** time domain specifications and error for standard inputs.
CO 4	**Apply** Routh-Hurwitz criterion and Root locus technique to **Analyze** the stability for LTI systems in time domain frame.
CO 5	**Apply** bode, polar and Nyquist plots to **Analyze** the stability for LTI systems in frequency domain frame.

Program Matrix

COs	**Program Outcomes (POs)**			PSO1
	PO1	PO2	PO3	
CO1	3	3	1	2
CO2	3	3	2	2
CO3	2	2	3	2
CO4	2	2	3	2
CO5	2	2	3	2

SYLLABUS

UNIT I: **[10 Periods]**

Transfer functions of linear systems-impulse response of linear systems-block diagrams of control systems signal flow graphs-reduction techniques for complex block diagrams and signal flow graphs.

UNIT II: **[8 Periods]**

Introduction to mathematical modelling of physical systems-equations of electrical networks-modelling of mechanical systems- equations of mechanical systems.

UNIT III: **[12 Periods]**

Time domain analysis of control systems-time response of first and second order systems with standard input signals-steady state performance of feedback control systems-steady state error constants-effect of derivative and integral control on transient and steady state performance of feedback control systems.

UNIT IV: **[10 Periods]**

Concept of stability and necessary conditions for stability-Routh-Hurwitz criterion, relative stability analysis, the concept and construction of root loci, analysis of control systems with root locus.

UNIT V: **[10 Periods]**

Correlation between time and frequency responses - polar plots, **b**ode plots-log magnitude versus phase plots all pass and minimum phase systems-Nyquist stability criterion-assessment of relative stability-constant M&N circles.

Text Books:

1. Control Systems Engineering by I.J. Nagrath& M.Gopal, Wiley Eastern Limited.

2. Automatic Control Systems by Benjamin C. Kuo, Prentice Hall of India.

Reference Book:

1. Modern Control Engineering by Ogata, Prentice Hall of India.

23CS 112: Advanced Drives & Control

Credits : 3 Lectures per week : 3

Univ. Exam. Marks : 60 Sessional Marks : 40

Total Marks : 100

CO 1	Analyze torque pulsations, propose control for waveform optimization.
CO 2	Apply Park's transform to model induction motors in dynamic scenarios.
CO 3	Evaluate slip power, choose VSI/CSI, optimize induction motor control.
CO 4	Design sensorless control, justify methods for induction motors.
CO 5	Compare magnet motors, select optimal drives for industrial applications.

Program Matrix

COs	Program Outcomes (POs)			PSO1
	PO1	PO2	PO3	
CO1	3	3	1	2
CO2	3	3	2	2
CO3	2	2	3	2
CO4	2	2	3	2
CO5	2	2	3	2

SYLLABUS

UNIT-I: **12 Lectures**

DC Drives: Introduction to four-quadrant operation, motor rating, motor mechanism dynamics, 1-ph fully controlled converter and chopper fed separately excited dc motor, effect of armature current waveform, torque pulsations. Dual converter fed separately excited dc motor.

UNIT-II: **12 Lectures**

Machine Modeling: Fundamentals of machine modelling. Modelling of separately excited dc motor. Park’s transformation. Dynamic d-q modelling of 3-ph induction motor and 3-ph synchronous motor.

UNIT-III: **12 Lectures**

Induction Motor Control: Scalar control techniques of 3–phase induction motor: Variable Voltage, Variable frequency, Variable voltage and variable frequency with constant v/f ratio, Rotor resistance control. Slip power recovery schemes. Comparison between VSI and CSI. (Using Power Electronic Converters).

UNIT-IV: **12 Lectures**

Vector Control & DTC of Induction Motor: Direct and Indirect vector control, sensor less vector control, direct torque and flux control.

UNIT-V: **12 Lectures**

Synchronous Motor Drives: Permanent magnet materials and their properties, Synchronous reluctance, sinusoidal and trapezoidal back emf permanent magnet motors, wound field machine drives, switched reluctance motor drives.

Text Books:

1. B. K. Bose, "Modern Power Electronics and AC drives", Pearson Education, Asia, 2003.
2. G. K. Dubey, "Fundamentals of Electrical Drives", Narosa Publishing house.
3. Power Electronics: converters, applications and design Ned Mohan 2nd edition john wiley sons Inc Nov 2002.
4. R. Krishnan, "Electric Motor Drives: Modeling, Analysis and Control", PH, 1998.

Reference Books:

1. V. Subrahmanyam, "Electric Drives-Concepts and Applications", TMH.
2. G. K. Dubey, "Power Semiconductor controlled drives", PH 1989.
3. P. Vas, "Sensor less vector and direct torque control", Oxford Press, 1998.
4. W. Leonard, "Control of Electric Drives", Springer Verlag, 1985.
5. M. H. Rashid, "Power Electronics", Third Edition, PHI.
6. Generalized Theory of Electrical Machines By Dr.P.S. Bhimbra, Khanna Publications.

23CS 113: Professional Elective-I-A (Large Scale Systems)

Credits : 3 | Lectures per week : 3

Univ. Exam. Marks : 60 | Sessional Marks : 40

Total Marks : 100

CO 1	Analyze aggregation methods for linear state space modeling.
CO 2	Apply Pade and Routh approximations in system modeling
CO 3	Synthesize multi-input, multi-output systems using matrix continued fractions.
CO 4	Evaluate control design for singularly perturbed linear systems.
CO 5	Design optimal controllers for fast-slow subsystems.

Program Matrix

COs	**Program Outcomes (POs)**			PSO1
	PO1	PO2	PO3	
CO1	3	3	1	2
CO2	3	2	2	2
CO3	2	2	3	2
CO4	2	2	3	2
CO5	3	2	3	2

SYLLABUS

UNIT-I: **12 Lectures**

L.S.S. Modelling: Time Domain: Introduction, Aggregation methods, exact and model aggregation by continued fraction, chained aggregation descriptive variables approach, descriptive variable systems, solvability and conditionality, time invariance, shuffle algorithm.

UNIT-II: **12 Lectures**

L.S.S. Modelling - Frequency Domain: Introduction, Moment matching, Pade approximation, Routh approximation, continued fraction method, error minimization methods, mixed methods and unstable systems.

UNIT-III: **12 Lectures**

L.S.S. Modelling - Frequency Domain: Pade model method, Pade-Routh method, multi-input and multi output systems, reduction, matrix continued fraction method, Model continued fraction method, Pade model method, frequency comparison method.

UNIT-IV: **12 Lectures**

Time Scales: Introduction, problem statement and preliminaries, numerical algorithm, basic properties, relation to model aggregation, feedback control design, singularly perturbed linear systems.

UNIT-V: **12 Lectures**

Singular Perturbations: Fast and slow sub systems, eigen value distribution, approximation to time scale approach, system properties, design of optimal controllers, fast and slow controllers, lower order controls.

TEXT BOOKS:

1. 'Large Scale Systems Modeling and Control', Mohammad Jamshidi,1989, North Hollard (Series in systems science and engineering, vol.9).
2. 'Large Scale Systems Modeling', Magdi S. Mohamoud and Madan G. Singh, Pergamon Press (International series on Systems and Control), 1981.

23CS 113: Professional Elective-I-B (Modern Control Systems)

Credits : 3 | Lectures per week : 3

Univ. Exam. Marks : 60 | Sessional Marks : 40

Total Marks : 100

CO 1	Apply state representation, analyze system dynamics, and illustrate state diagrams.
CO 2	Calculate solutions, determine modes, and evaluate matrix exponentials for systems.
CO 3	Assess system control and observability, apply tests, and realize systems.
CO 4	Analyze equilibrium points, assess stability, and apply Lyapunov methods.
CO 5	Employ state feedback, design pole placement, and implement observers.

Program Matrix

COs	**Program Outcomes (POs)**			PSO1
	PO1	PO2	PO3	
CO1	2	2	-	2
CO2	3	2	2	2
CO3	2	2	3	2
CO4	2	2	3	2
CO5	2	2	3	2

SYLLABUS

UNIT-I: **12 Lectures**

State variable representation: Introduction-Concept of State-State equation for Dynamic Systems-Time invariance and linearity-No uniqueness of state model-State Diagrams-Physical System and State Assignment.

UNIT-II: **12 Lectures**

Solution of state equation: Existence and uniqueness of solutions to Continuous-time state equations-Solution of Nonlinear and Linear Time Varying State equations- Evaluation of matrix exponential-System modes-Role of Eigenvalues and Eigenvectors.

UNIT-III: **10 Lectures**

Controllability and Observability: Controllability and Observability-Stabilizability and Detectability-Test for Continuous time Systems- Time varying and Time invariant case-Output Controllability-Reducibility- System Realizations.

UNIT-IV: **14 Lectures**

Stability: Introduction-Equilibrium Points-Stability in the sense of Lyapunov-BIBO Stability-Stability of LTI Systems-Equilibrium Stability of Nonlinear Continuous Time Autonomous Systems-The Direct Method of Lyapunov and the Linear Continuous-Time Autonomous Systems-Finding Lyapunov Functions for Nonlinear Continuous Time Autonomous Systems-Krasovskii and Variable-Gradient Method.

UNIT-V: **12 Lectures**

Modal control: Introduction-Controllable and Observable Companion Forms-SISO and MIMO Systems- The Effect of State Feedback on Controllability and Observability-Pole Placement by State Feedback for both SISO and MIMO Systems-Full Order and Reduced Order Observers.

TEXT BOOKS:

1. M. Gopal, “Modern Control System Theory”, New Age International, 2005.

2. K. Ogata, “Modern Control Engineering”, PHI, 2002.

REFERENCES:

1. John S. Bay, “Fundamentals of Linear State Space Systems”, McGraw-Hill, 1999.

2. D. Roy Choudhury, “Modern Control Systems”, New Age International, 2005.

3. John J. D’Azzo, C. H. Houpis and S. N. Sheldon, “Linear Control System Analysis and Design with MATLAB”, Taylor Francis, 2003.

4. Z. Bubnicki,” Modern Control Theory”, Springer, 2005.

23CS 113: Professional Elective-I-C (Control Systems Components)

Credits : 3 Lectures per week : 3

Univ. Exam. Marks : 60 Sessional Marks : 40

Total Marks : 100

CO 1	Analyze gyroscopes, potentiometers; evaluate their applications and selection criteria.
CO 2	Evaluate tachometers, synchros; appraise construction, working principles, and applications.
CO 3	Assess stepper motors, servomotors; analyze working, types, applications, and control methods.
CO 4	Evaluate magnetic amplifiers, servo amplifiers; appraise construction, types, characteristics.
CO 5	Analyze MEMS, accelerometers; examine definitions, classifications, and applications.

Program Matrix

COs	**Program Outcomes (POs)**			PSO1
	PO1	PO2	PO3	
CO1	2	2	-	2
CO2	2	2	2	2
CO3	2	2	2	2
CO4	2	2	2	2
CO5	2	2	2	2

SYLLABUS

UNIT-I: **14 Lectures**

Gyroscopes and Potentiometers: Working of gyroscopes, types of gyroscopes and their generalized mathematical model, applications of horizontal and vertical gyroscopes. Types of potentiometers, applications of potentiometers and selection of potentiometers.

UNIT-II: **10 Lectures**

Tachometers and Synchros: Construction details, e.m.f equation of tachometers, types of tachometers, characteristics of tachometers, tachometer applications. Constructional details and working of Synchros, Principles of Resolvers and Decoders

UNIT-III: **12 Lectures**

Stepper Motors and Servomotors: Working principle of Stepper motor, types – permanent magnet stepper motor, reluctance type stepper motor, hybrid stepper motor, Applications of stepper motor. Servomotors types, DC servomotors, AC servomotors – transfer functions, speed control methods (armature controlled & field controlled).

UNIT-IV: **12 Lectures**

Magnetic Amplifiers and Servo Amplifiers: construction, types of magnetic amplifiers – series, parallel and self saturated magnetic amplifiers, Characteristics of magnetic amplifiers, features of servo amplifiers, DC and AC servo amplifiers.

UNIT-V: **12 Lectures**

MEMS and Accelerometers: Introduction to MEMS, definitions, classification and applications. Introduction to the Accelerometer and types of accelerometers.

TEXT BOOKS:

1. Gibson T.E. and Tetuer F.B, “Control System Components”, McGraw Hill, New York 1993.
2. Desai M.D, “Control System Components”, PHI Learning Pvt. Ltd., 2008.
3. Nadim Maluf and Kirt Williams “An Introduction to Microelectromechanical Systems Engineering” Second edition.
4. Control System Engineering, J.Nagrath and M.Gopal New Age International Publishers, 5th Edition, 2007

23CS 114: Professional Elective-II-A (Robotics)

Credits : 3 | Lectures per week : 3
Univ. Exam. Marks : 60 | Sessional Marks : 40
Total Marks : 100

CO 1	Analyze robot structure, end effectors, and wrist configuration concepts.
CO 2	Evaluate robot classifications, motion forms, and control methods.
CO 3	Apply Newton-Euler equations, Lagrangian analysis, and homogeneous coordinates.
CO 4	Analyze open/closed loop control, manipulator Jacobians, and control schemes.
CO 5	Evaluate robot applications: welding, painting, handling, assembly, power plants.

Program Matrix

COs	**Program Outcomes (POs)**			PSO1
	PO1	PO2	PO3	
CO1	2	2	-	2
CO2	2	2	2	2
CO3	2	2	2	2
CO4	2	2	2	2
CO5	2	2	2	2

SYLLABUS

UNIT-I: **10 Lectures**

Fundamentals of Robot Technology: Basic structure, links and Joints, types of Joints, types of links, types of end effectors: Grippers: Mechanical, Vacuum cups, Magnetic, adhesive and miscellaneous. Tools as end effectors. Wrist configuration: concept of: yaw, pitch and roll.

UNIT-II: **14 Lectures**

Robot classification: According to Co-ordinate system: Cartesian, cylindrical, spherical, SCARA, Articulated; Control Method: Servo controlled and non-servo controlled, their comparative study; Form of motion: P-T-P (point to point), C-P (continuous path), pick and place etc. and their comparative study; Motion conversion: Rotary to rotary, rotary to linear and vice versa.

UNIT-III: **12 Lectures**

Robot arm dynamics: Newton Euler Equations, Kinetic and potential energy, Lagrangian analysis for a single prismatic joint working against gravity and single revolute joint. Joint vector, homogeneous co-ordinates. Matrix operators for translation and rotation

UNIT-IV: **12 Lectures**

Robot Control: Open loop and closed loop control, Linear control Schemes, PD and PID control, Torque and Force control of robotic manipulators, Adaptive control, Hybrid control, Impedance control. Manipulator Jacobian, Jacobian for prismatic and revolute joint. Jacobian Inverse, Singularities, Control of Robot manipulator: joint position controls (JPC), resolved motion position controls (RMPC) and resolved motion rate control (RMRC)

UNIT-V: **12 Lectures**

Industrial Applications: Industrial Applications of Robots: Welding, Spray-painting, Grinding, Handling of rotary tools, Parts handling/transfer, Assembly operations, parts sorting, parts inspection, Potential applications in Nuclear and fossil fuel power plant etc.

TEXT BOOKS

1. R. K. Mittal, I. J. Nagrath, "Robotics and Control", Tata McGraw Hill Publishing Company Ltd., NewDelhi.
2. Robert J. Schilling, "Fundamentals of Robotics: Analysis and Control", Prentice Hall of India, NewDelhi
3. John J. Craig, "Introduction to Robotics: Mechanics and Control", Pearson Education
4. Mikell P. Groover, Mitchell Weiss, Roger N. Nagel, Nicholas G. Odrey, "Industrial Robotics: Technology, Programming and Applications", McGraw Hill Book Company
5. Richard D. Klafter, Thomas A. Chemielewski, Michael Neign "Robotic Engineering – An Integral Approach", Prentice Hall of India Pvt. Ltd., New Delhi. Eastern Economy Edition.

23CS 114: Professional Elective-II-B (DIGITAL CONTROL SYSTEMS)

Credits : 3 Lectures per week : 3

Univ. Exam. Marks : 60 Sessional Marks : 40

Total Marks : 100

CO 1	Understand the fundamentals of discrete-time systems and their structure.
CO 2	Model digital control systems, analyze transfer functions, and error characteristics.
CO 3	Analyze stability of discrete-time control systems using stability criteria.
CO 4	Apply state space representation, analyze stability, and controllability of discrete-time systems.
CO 5	Design state feedback control, solve servo problems, and use pole placement techniques.

Program Matrix

COs	**Program Outcomes (POs)**			PSO1
	PO1	PO2	PO3	
CO1	2	2	-	2
CO2	2	2	1	2
CO3	2	2	2	2
CO4	2	2	2	2
CO5	2	2	2	2

SYLLABUS

UNIT-I: **14 Lectures**

Discrete-Time Systems: Why Digital Control, The Structure of a Digital Control System, Analog Systems with Piecewise Constant Inputs, Difference Equations, the Z-Transform, Computer-Aided Design, Z-Transform Solution of Difference Equation, The Time Response of a Discrete-Time System, The Modified Z-Transform, Frequency Response of Discrete-Time Systems, The Sampling Theorem, Resources, Problems.

UNIT-II: **12 Lectures**

Modeling of Digital Control Systems: ADC Model, DAC Model, Transfer Function of the ZOH, Effect of Sampler on Transfer Function of a Cascade, Transfer Function for the DAC, Analog Subsystem, ADC Combination, Systems with Transport Lag, the Closed-Loop Transfer Function, Analog Disturbances in a Digital System, Steady-State Error and Error Constants.

UNIT-III: **10 Lectures**

Stability of Digital Control Systems: Definitions of Stability, Stable Z-Domain Pole Locations, Stability Conditions, Stability Determination, Jury Test, Nyquist Criterion, Resources, Problems, Computer Exercises.

UNIT-IV: **12 Lectures**

State Space Representation: Discrete-Time State Space Equations, Solution of Discrete-Time, State Space Equations, Z-Transfer from State Space Equations, Similarity Transformation, Resources, Problems, Computer Exercises. Stability of State Space Realizations, Controllability and Stabilizability, Observability and Detectability.

UNIT-V: **12 Lectures**

State Feedback Control: On State and Output Feedback, Pole Placement, Servo Problem, Invariance of System Zeros, State Estimation, Observer State Feedback, Pole Assignment Using Transfer Functions, Resources, Problems, Computer Exercises.

Text Books:

1. Digital Control Engineering: Analysis and Design, By M. Sami Fadali, Antonio Visioli, Academic Press, 2019
2. Digital control systems by B.C. Kuo, second edition, Saunders college publication-2012.
3. Digital Control Systems by Ogata.
4. Digital Control Systems (Software & Hardware) By Laymount & Azzo.

23CS 114: Professional Elective-II-C (Optimization Techniques)

Credits : 3 Lectures per week : 3

Univ. Exam. Marks : 60 Sessional Marks : 40

Total Marks : 100

CO 1	Understand the fundamentals of classical optimization techniques and problem classification.
CO 2	Apply single and multi-variable optimization methods with and without constraints.
CO 3	Apply linear programming techniques, simplex method, and two-phase method.
CO 4	Analyze unconstrained and constrained nonlinear optimization methods.
CO 5	Design and implement methods of feasible directions for constrained optimization.

Program Matrix

COs	**Program Outcomes (POs)**			PSO1
	PO1	PO2	PO3	
CO1	3	2	1	2
CO2	3	2	1	2
CO3	3	2	2	2
CO4	3	2	2	2
CO5	3	2	2	2

SYLLABUS

UNIT-I: **8 Lectures**

Introduction to Classical Optimization Techniques: Statement of an Optimization problem – design vector – design constraints – constraint surface – objective function – objective function surfaces – classification of Optimization problems.

UNIT-II: **12 Lectures**

Classical Optimization Techniques: Single variable Optimization, Multi variable Optimization with and without constraints, Multivariable Optimization with equality constraints - solution by method of Lagrange multipliers, Multivariable Optimization with inequality constraints - Kuhn – Tucker conditions.

UNIT-III: **14 Lectures**

Linear Programming: Introduction, Applications of Linear Programming, Standard Form of a Linear Programming, Basic Terminology and Definitions, Exceptional cases, Simplex method, Big-M method, Two- phase method

UNIT-IV: **14 Lectures**

Non-Linear Programming-I: Unconstrained optimization-Univariate method, Pattern Directions, Hook and Jeeves Method, Powell's method, Gradient of a function, Steepest descent method, Conjugate Gradient Method, Newton's method, Marquardt Method, Quai-Newton Methods, Davidon-Fletcher-Powell Method, Broyden-Fletcher-Goldfarb-Shanno Method.

UNIT-V: **14 Lectures**

Non-Linear Programming-II: Constrained optimization- Characteristics of a Constrained Problem, Sequential linear programming, Basic approach in the methods of feasible directions, Zoutendijk's method of feasible directions, Sequential Quadratic Programming.

TEXT BOOKS:

1. Engineering Optimization: Theory and Applications' By S.S.Rao, New Age International Publishers, Third Edition
2. Engineering optimization: Theory and practice"-by S.S.Rao, New Age International (P) Limited.
3. Operations Research: An Introduction" by H A Taha, 5th Edition, Macmillan, New York.

23CS 115: Research Methodology & IPR

Credits : 3 Lectures per week : 3

Sessional Marks : 100 Total Marks : 100

CO 1	Understand the research process, problem formulation, and types of research.
CO 2	Conduct effective literature surveys, collect primary and secondary data.
CO 3	Design experiments, apply statistical concepts, and analyze experimental data
CO 4	Create comprehensive research proposals and reports, adhere to ethics.
CO 5	Understand Intellectual Property Rights (IPR) and its application.

Program Matrix

COs	**Program Outcomes (POs)**			PSO1
	PO1	PO2	PO3	
CO1	3	2	2	2
CO2	3	2	1	2
CO3	3	2	2	2
CO4	3	2	2	2
CO5	3	2	2	2

SYLLABUS

UNIT-I: **12 Lectures**

Research Problem Formulation: Meaning of research, Objectives of Research, Types of research, Significance of Research, Research process, Selecting the problem, Necessity of defining the problem, Meaning of Research design, Need for research design, features of a good design, Different research designs.

UNIT-II: **12 Lectures**

Literature Survey: Quantitative and Qualitative data, Scaling, Scaling Techniques, Experiments and Surveys, Collection of primary and secondary data, Data preparation process. Research problems, Effective literature studies approaches, Survey for existing literature, Procedure for reviewing the literature, analysis and assessment.

UNIT-III: **12 Lectures**

Design of Experiments: Strategy of Experimentation - Typical applications of experimental design, Guidelines for designing experiments; Basic statistical concepts - Statistical concepts in experimentation, Regression approach to analysis of variance.

UNIT-IV: **12 Lectures**

Research proposal and writing: Contents of a research proposal, Writing a research report- Research writing in general, Referencing, Writing a bibliography, Presentation and assessment by a review committee, Plagiarism, Research ethics.

UNIT-V: **12 Lectures**

Intellectual Property Rights: Intellectual Property Definition, WTO, Fundamentals of Patent, Copyright, The rights of the owner, Term of copyright, Register of trademark, Procedure for trade mark, Term of trademark; New Developments in IPR- Administration of patent system, IPR of Biological Systems, Computer Software

REFERENCES:

1. C.R Kothari, Research Methodology, Methods & Technique; New Age International Publishers, 2018.

2. R. Ganesan, Research Methodology for Engineers, MJP Publishers, 2011.

3. Ratan Khananabis and Suvasis Saha, Research Methodology, Universities Press, Hyderabad, 2015.

4. Y. P. Agarwal, Statistical Methods: Concepts, Application and Computation, Sterling Publs., Pvt., Ltd., New Delhi, 2004.

5. Vijay Upagade and Aravind Shende, Research Methodology, S. Chand & Company Ltd., New Delhi, 2009.

6. Prahalad Mishra, “ Business Research Methods “ Oxford 2016.

23CS 116: Control Systems Lab

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

CO 1	Determine the transfer functions of DC and AC servomotor
CO 2	To analyze the performance of synchro pair, BLDC motor, DC position control system and Magnetic amplifier
CO 3	To analyze the response of 1^{st}, 2^{nd} and 3^{rd} order systems with and without feedback
CO 4	Design of compensators using Bode plot techniques
CO 5	Estimate the effect of Temperature controlled system using conventional controllers

Program Matrix

COs	**Program Outcomes (POs)**			PSO1
	PO1	PO2	PO3	
CO1	2	3	3	2
CO2	2	3	3	2
CO3	2	3	3	2
CO4	2	3	3	2
CO5	2	3	3	2

LIST OF EXISTING EXPERIMENTS

S. No.	Experiment Name
1	Study of Lead, Lag and Lead-Lag compensating networks
2	Speed - Torque characteristics of a DC servomotor
3	To study the 'Magnetic Amplifier'
4	Linear system simulator
5	Speed torque characteristics of A.C. Servo motor
6	Synchro transmitter and receiver pair
7	DC Motor Speed control characteristics
8	To study the D.C Position control system
9	To study the temperature controller using P, PI, PD and PID modes of operation.
10	To study the performance of BLDC motor.

SEMESTER – II

23CS121: Advanced Control Systems and Design

Credits : 3 | Lectures per week : 3

Univ. Exam. Marks : 60 | Sessional Marks : 40

Total Marks : 100

CO 1	Apply compensation techniques for linear control systems to achieve desired performance.
CO 2	Optimize control system parameters using integral-square error criterion.
CO 3	Design MIMO control systems using linear quadratic optimal regulators and observers
CO 4	Apply PID control and various compensator structures to control systems.
CO 5	Design digital control systems, regulators, and observers for discrete-time systems.

Program Matrix

COs	**Program Outcomes (POs)**			PSO1
	PO1	PO2	PO3	
CO1	2	3	3	2
CO2	2	3	3	2
CO3	2	3	3	2
CO4	2	3	3	2
CO5	2	3	3	2

SYLLABUS

UNIT-I: **12 Lectures**

Design of Linear Control Systems: Review of compensation technique and choice of optimum parameters to obtain desired performance, Reshaping of Polar, Bode, Root locus plots to obtain desired response, Initial condition and forced response, a simple lag – lead design.

UNIT-II: **12 Lectures**

Integral-square error compensation: parameter optimization using Integral-square error criterion with and without constraints, State variable Feedback compensation of continuous - time and discrete- time systems.,

UNIT-III: **12 Lectures**

MIMO Control design: Matching Based on Linear Quadratic Optimal Regulators, Discrete Time Optimal Regulators, Connections to Pole Assignment, Observer Design, Linear Optimal Filters, State Estimate Feedback, Transfer Function Interpretation, Achieving Integral Action in LQR Synthesis, Industrial Applications.

UNIT-IV: **12 Lectures**

PID Controller: Tunable PID controller, Ziegler – Nichol's method, Simulation of multi-loop control system using P, PI, PD, PID controller and finding the system response. Standard compensator structures (P, PD, PI and PID control).

UNIT-V: **12 Lectures**

Design of digital control system: Digital controller design, Regulator and observer design, Digital servo for inverted pendulum. Classical Compensation of Discrete-time control systems: Forward path continuous, Forward-path Digital, Z-plane Synthesis approaches, Deadbeat performance.

Text Books:

1. G. C. Goodwin, S. F. Graebe, M. E. Salgado, "Control System Design", Prentice Hall of India

2. Gupta and Hasdorf, 'Fundamentals of Automatic control Willey Eastern.

3. B.C.Kuo, Automatic control systems' (5th Edition), Prentice Hall of India.

4. Hadi Saadat, "Computational Aids in Control System Using MATLAB", McGraw Hill

5. M. Gopal, "Control Systems Principles and Design", 2nd Edition, Tata McGraw Hill

23CS122: Nonlinear Control Systems

Credits : 3 | Lectures per week : 3

Univ. Exam. Marks : 60 | Sessional Marks : 40

Total Marks : 100

CO 1	Understand the classification and types of non-linear systems, critical jump phenomena.
CO 2	Analyze non-linear systems using phase plane analysis and stability methods.
CO 3	Apply frequency domain analysis and describing function method for stability.
CO 4	Understand Lyapunov stability concepts for autonomous systems.
CO 5	Apply linearization techniques and feedback/input-output linearization.

Program Matrix

COs	**Program Outcomes (POs)**			PSO1
	PO1	PO2	PO3	
CO1	2	2	3	2
CO2	2	2	3	2
CO3	2	2	3	2
CO4	2	2	3	2
CO5	2	2	3	2

SYLLABUS

UNIT-I: **12 Lectures**

Introduction to Non-Linear System: Classification of non-linearity, types of non-linearity in physical system, jump phenomena and critical jump resonance curve, methods of analysis of non-linear systems and comparison, isoclines, singular point, limit cycle.

UNIT-II: **12 Lectures**

Phase Plane Analysis: Concept of phase plane, phase trajectory, phase portraits, methods of plotting phase plane trajectories Vander Pol's equation, stability from phase portrait, time response from trajectories, isoclines method, Pell's method of phase trajectory, and Delta method of phase trajectory construction.

UNIT-III: **12 Lectures**

Frequency Domain Analysis: Absolute stability, describing function, DF of typical nonlinearities stability analysis using DF method, stability studies using DF method.

UNIT-IV: **12 Lectures**

Lyapunov Stability: Autonomous Systems: Stability of equilibrium point. Concepts of positive definite/semi definite, negative definite/ semi definite, indefinite functions, Lyapunov function, Lyapunov Stability: asymptotic stability, global asymptotic stability, instability.

UNIT-V: **12 Lectures**

Linearization: Linear systems, linearization of nonlinear systems about equilibrium point, feedback linearization and input/output linearization.

TEXT BOOK:

1. M. Vidyasagar, 'Nonlinear systems Analysis', 2nd Edition, 1991, prentice-Hall Inc.

REFERENCE BOOK:

1. Control Systems Theory and Application: Samarjit Ghosh, Pearson Education
2. Control System Engineering: Nagrath and Gopal, Wiley Eastern
3. Automatic Control System: George J. Thaler Brown, Jaico Publications
4. Nonlinear Systems: Hasan A. Khalil, Printece Hall of India

23CS123: Optimal & Adaptive Control

Credits : 3 — Lectures per week : 3

Univ. Exam. Marks : 60 — Sessional Marks : 40

Total Marks : 100

CO 1	Understand the formulation of optimal control problems and state variable representation.
CO 2	Apply dynamic programming and calculus of variations for optimal control.
CO 3	Understand the variational approach and necessary conditions for optimal control.
CO 4	Apply adaptive control techniques, model reference adaptive control.
CO 5	Design state feedback direct model reference adaptive control systems.

Program Matrix

COs	Program Outcomes (POs)			PSO1
	PO1	PO2	PO3	
CO1	2	-	3	2
CO2	2	2	3	2
CO3	2	2	3	2
CO4	2	2	3	2
CO5	2	2	3	2

SYLLABUS

UNIT I: **14 Lectures**

Introduction - Problem formulation- State variable representation of systems Performance measures for optimal control problems–selecting a performance measure. Dynamic programming – optimal control law – principal of optimality – discrete linear regulator problems -Hamilton- Jacobi-Bellman equation-continuous linear regulator problem.

UNIT II: **10 Lectures**

The Calculus of variations: Fundamental concepts- the fundamental theorem of the calculus of variations - Functional of a single function- the simplest variational problem.

UNIT III: **10 Lectures**

The variational approach to optimal control problems-Necessary conditions for optimal control - Linear regulator problem pontryacyn's minimum principle and state inequality constraints

UNIT IV: **14 Lectures**

Introduction what is Adaptive control? Effect of process variations–Adaptive Schemes–Adaptive control problem Model Reference Adaptive Control- Motivational Example, Introduction to Direct Model Reference Adaptive Control, Direct Model Reference Adaptive Control of Scalar Linear Systems with Parametric Uncertainties.

UNIT V: **12 Lectures**

State Feedback Direct Model Reference Adaptive Control: Introduction, Command Tracking, Direct MRAC Design for Scalar Systems, Dynamic Inversion MRAC Design for Scalar Systems.

TEXT BOOK:

1. Optimal control theory-An Introduction by Donald E.Kirk - Prentice Hall Networks series.
2. Robust and Adaptive Control: With Aerospace Applications, Advanced textbooks in control and signal processing, by Eugene Lavretsky, Kevin A. Wise, publisher Springer

23CS124: Professional Elective-III-A (Sliding Mode Control)

Credits : 3 | Lectures per week : 3

Univ. Exam. Marks : 60 | Sessional Marks : 40

Total Marks : 100

CO 1	Understand the principles and properties of sliding mode control.
CO 2	Analyze sliding mode control, its existence, and equivalent control properties.
CO 3	Design sliding mode control approaches and apply them to specific cases.
CO 4	Design sliding mode controllers using output information.
CO 5	Synthesize sliding mode observers and apply them for fault detection.

Program Matrix

COs	**Program Outcomes (POs)**			**PSO1**
	PO1	PO2	PO3	
CO1	2	-	2	2
CO2	2	2	3	2
CO3	2	2	3	2
CO4	2	2	3	2
CO5	2	2	2	2

Subjects

UNIT-I: **12 Lectures**

An Introduction to Sliding Mode Control: Introduction, properties of sliding motion, typical controller design, pseudo-sliding with a smooth control action, a state-space approach

UNIT-II: **10 Lectures**

Sliding mode control: Introduction, problem statement, existence of solution and equivalent control properties of the sliding motion, The reachability problem, the unit vector approach, continuous approximations.

UNIT-III: **12 Lectures**

Sliding mode Design approaches: Introduction, A regulator form-based approach, a direct eigen structure assignment approach, Incorporation of a tracking requirement, Design study of Pitch- pointing flight controller.

UNIT-IV: **12 Lectures**

Sliding mode controllers using output information: Introduction, problem formulation, a special case of square plants, a general frame work, dynamic compensation, observer based dynamic compensation, a model reference system using only outputs.

UNIT-V: **12 Lectures**

Sliding mode observers: Introduction, sliding mode observers, synthesis of a discontinuous observer, the Walcott-Zak observer revisited, sliding mode observers for fault detection

TEXT BOOKS:

1. Sliding Mode Control: Theory and Applications (Series in Systems and Control) by C Edwards and S Spurgeon, Published by Taylor & Francis
2. Sliding Mode Control In Engineering (Automation and Control Engineering) by Wilfrid Perruquetti , Jean-Pierre Barbot published by Marcel Dekker, Inc, New York

23CS124: Professional Elective-III-B (Process Control & Automations)

Credits : 3 | Lectures per week : 3

Univ. Exam. Marks : 60 | Sessional Marks : 40

Total Marks : 100

CO 1	Understand the fundamentals of process modelling and empirical model development.
CO 2	Design and analyze feedback and feedforward control systems using various techniques.
CO 3	Apply advanced process control techniques, multi-loop control, and optimization.
CO 4	Implement model predictive control and understand plant wide control and monitoring.
CO 5	Apply statistical process control, fuzzy logic, and understand environmental aspects in process industries.

Program Matrix

COs	Program Outcomes (POs)			PSO1
	PO1	PO2	PO3	
CO1	2	-	2	2
CO2	2	2	3	2
CO3	2	2	3	2
CO4	2	2	3	2
CO5	2	2	3	2

Subjects

UNIT-I: **12 Lectures**

Process Modelling: Introduction to Process control and process instrumentation-Hierarchies in process control systems-Theoretical Model, Transfer function, State space models-Time series model Development of empirical models from process data-chemical reactor modelling-. Analysis using MATLAB & SIMULINK.

UNIT-II: **14 Lectures**

Feedback & Feed forward Control: Feedback controllers-PID design, tuning, troubleshooting Control system design based on Frequency response Analysis-Direct digital design-Feed forward and ratio control-State feedback control- LQR problem- Pole placement -Simulation using MATLAB & SIMULINK-Control system instrumentation-Control valves- Codes and standards- Preparation of P& I Diagrams.

UNIT-III: **12 Lectures**

Advanced process control: multi-loop and multivariable control-Process Interactions-Singular value analysis-tuning of multi loop PID control systems-decoupling control-strategies for reducing control loop interactions-Real-time optimization-Simulation using MATLAB & SIMULINK.

UNIT-IV: **10 Lectures**

Model predictive control-Batch Process Control-Plant-wide control & monitoring- Plant wide control design

UNIT-V: **12 Lectures**

Instrumentation for process monitoring-Statistical process control-Introduction to Fuzzy Logic in Process Control-Introduction to OPC-Introduction to environmental issues and sustainable development relating to process industries. Comparison of performance different types of control with examples on MATLAB and SIMULINK.

Textbooks:

1. Seborg, D.E., T.F. Edgar, and D.A. Mellichamp, Process Dynamics and Control, John Wiley, 2004
2. Johnson D Curtis, Instrumentation Technology, (7th Edition) Prentice Hall India, 2002.
3. Bob Connel, Process Instrumentation Applications Manual, McGrawHill

23CS124: Professional Elective-III-C (Hybrid Electrical Vehicles)

Credits : 3 | Lectures per week : 3
Univ. Exam. Marks : 60 | Sessional Marks : 40
Total Marks : 100

CO 1	**Associate** with the history of hybrid vehicles and physics involved in the conventional vehicle movement to **Calculate** the total tractive force required for vehicle motion.
CO 2	**Classify** various types of hybrid vehicle configurations to **interpret** their compatibility in specific applications.
CO 3	**Identify** specific configuration of electric vehicle, electric drive machine and power converter as per the requirement to **Analyze** the performance of system design.
CO 4	**Distinguish** the features and suitability of energy storage devices to **Relate** them as per the requirement.
CO 5	**Compare** various energy management strategies to **Select** them appropriately in specific EHV/EV controller design.

Program Matrix

COs	**Program Outcomes (POs)**			**PSO1**
	PO1	PO2	PO3	
CO1	2	1	2	2
CO2	2	1	3	2
CO3	2	2	3	2
CO4	2	1	3	2
CO5	2	2	3	2

Subjects

UNIT-I: **12 Lectures**

INTRODUCTION OF VEHICLES:

Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, and mathematical models to describe vehicle performance.

Electric Hybrid Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies.

UNIT-II: **12 Lectures**

HYBRID ELECTRIC DRIVE-TRAINS

Basic concept of hybrid traction, various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.

UNIT-III: **12 Lectures**

ELECTRIC DRIVE-TRAINS

Basic concept of electric traction, various electric drive train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis.

UNIT-IV: **12 Lectures**

Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.

UNIT-V: **12 Lectures**

ENERGY STORAGE

Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices.

Sizing the Drive System: matching the electric machine and the internal combustion engine (ICE), sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems.

TEXT BOOKS

1. C. Mi, M. A. Masrur and D. W. Gao, “Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives”, John Wiley & Sons, 2011.

2. S. Onori, L. Serrao and G. Rizzoni, “Hybrid Electric Vehicles: Energy Management Strategies”, Springer, 2015.

3. M. Ehsani, Y. Gao, S. E. Gay and A. Emadi, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design”, CRC Press, 2004.

4. T. Denton, “Electric and Hybrid Vehicles”, Routledge, 2016.

23CS 125: Professional Elective-IV-A (Intelligent Systems & Control)

Credits : 3 | Lectures per week : 3

Univ. Exam. Marks : 60 | Sessional Marks : 40

Total Marks : 100

CO 1	Understand the basic properties of artificial neural networks and their learning algorithms.
CO 2	Apply artificial neural networks in control systems and electrical engineering.
CO 3	Understand the concepts of fuzzy logic, fuzzy sets, and fuzzy inference systems.
CO 4	Analyze and design fuzzy controllers for static and dynamic properties.
CO 5	Design and implement neuro-fuzzy controllers and hybrid systems..

Program Matrix

COs	**Program Outcomes (POs)**			**PSO1**
	PO1	PO2	PO3	
CO1	2	-	3	2
CO2	2	2	3	2
CO3	2	2	3	2
CO4	2	1	3	2
CO5	2	2	3	2

SYLLABUS

UNIT-I: **14 Lectures**

Neural Networks: Artificial Neural Networks: Basic properties of Neurons, Neuron Models, Feedforward networks – Perceptron's, Multilayer networks – Exact and approximate representation, Back propagation algorithm, variants of Back propagation, representation of supervised, Unsupervised and Reinforcement learning; Competitive learning and self-organizing networks. [Text: 1]

UNIT-II: **10 Lectures**

ANN based control: Introduction, Representation and identification, modeling the plat, control structures – supervised control, study-application to electrical engineering. [Text: 3 chaper 6]

UNIT-III: **12 Lectures**

Fuzzy Logic: Overview of classical logic, Fuzzy sets vs Crisp set, Membership function, Methods of Membership function, Value Assignment, Defuzzification, Methods of defuzzification, fuzzy rule based and Approximation, Aggregation of Fuzzy rules, Fuzzy inference system –Mamdani and Sugeno methods. [Ref: 2 & 9]

UNIT-IV: **12 Lectures**

Fuzzy Controllers: Preliminaries – Basic architecture and operation of Fuzzy controller – Analysis of static properties of fuzzy controller – Analysis of dynamic properties of fuzzy controller – application to electrical engineering (PID Controllers for Servo Mechanic Systems). [Ref: 2,8 & 11]

UNIT-V: **12 Lectures**

Neuro–Fuzzy Controllers: Hybrid systems, Fuzzy logic in learning algorithm, fuzzy neurons, NN as Pre-processors, Architecture based on Back propagation, Adaptive neuro-fuzzy Inference systems (ANFIS). [Ref: 7 Chapter:17]

TEXT BOOKS:

1. Bose and Liang, Artificial Neural Networks, Tata Mcgraw Hill, 1996.
2. Kosco B, Neural Networks and Fuzzy Systems: A Dynamic Approach to Machine Intelligence, Prentice Hall of India, New Delhi, 1992.
3. George William Irwin, K. Warwick, Kenneth J. Hunt: Neural Network Applications in Control Institution of Electrical Engineers, London, United Kingdom, 1995.

REFERENCES:

1. Klir G.J and Folger T.A, Fuzzy sets, Uncertainty and Information, PHI, New Delhi 1994.
2. Simon Haykin, Neural Networks, ISA, Research Triangle Park, 1995.
3. Bose, Nirmal K.; Bose, N. K.; Liang, Ping, Neural Network Fundamentals with Graphs, Algorithms, and Applications (McGraw-Hill Series in Electrical & Computer Engineering)
4. R.Alavala Chennakesava, "Fuzzy logic and NN based concepts and applications", New age International publishers, 1998.
5. Fuzzy logic with Fuzzy Applications – T.J.Ross – Mc Graw Hill Inc, 1997.
6. S.N. Sivanandam, S. Sumathi and S.N. Deepa,; Introduction to Fuzzy Logic using MATLAB, Springer, 2007.
7. Ernest Czogala, Jacek Lesk , Fuzzy and Neuro-Fuzzy Intelligent Systems, Springer, 2000.
8. G. Chen, Introduction to Fuzzy sets, Fuzzy logic, fuzzy systems, CRC Press, Boca Raton Landon New York Washington, D.C. 2001.

23CS125: Professional Elective-IV-B (Modeling and Control of Power Converters)

Credits : 3 Lectures per week : 3

Univ. Exam. Marks : 60 Sessional Marks : 40

Total Marks : 100

CO 1	Understand the characteristics and operation of power semiconductor devices and gate driver circuits.
CO 2	Analyze various types of DC-DC converters, their control methods, and efficiency calculations
CO 3	Derive dynamic and small-signal models of DC-DC converters and understand their transfer functions.
CO 4	Analyze voltage source inverters (VSI), control methods, and understand AC-DC converters' principles and operation.
CO 5	Design voltage regulation and control strategies for power converters, including sliding mode and H-α control.

Program Matrix

COs	**Program Outcomes (POs)**			**PSO1**
	PO1	PO2	PO3	
CO1	2	-	2	2
CO2	2	2	3	2
CO3	2	2	3	2
CO4	2	1	3	2
CO5	2	2	3	2

Subjects

UNIT-I: **12 Lectures**

Review of power semiconductor devices: VI-Characteristics (ideal and practical), gate driver circuits. DC-DC Converters: various types, analysis, control of converter, duty ratio control and current & voltage control.

UNIT-II: **12 Lectures**

DC Analysis of PWM Buck, boost, buck-boost, flyback converter for CCM and DCM, Power Losses and Efficiency calculations.

UNIT-III: **12 Lectures**

Dynamic and output equations of the DC-DC converter, averaged model of the DC-DC converter, generalized state space model of the converter. Small-signal models of PWM DC-DC Converters and transfer function of the DC-DC converters

UNIT-IV: **12 Lectures**

Voltage Source Inverters (VSI): principle and steady state analysis of VSI, methods for controlling inverter, equivalent circuit. AC To DC Converters: line commutated & PWM converter, multiquadrant operation, regeneration, input current and reactive power requirements. Converter applications

UNIT-V: **12 Lectures**

Voltage regulation of power converter using P, PI, PD, and PID. Sliding mode controller, H-α controller

Books:

1. N. Mohan, T. Undeland, and W. Robbins, "Power Electronics Converters, Applications, and Design," Third edition, 2003, John Wiley and Sons Inc.
2. M.H. Rashid. "Power Electronics, circuit, Devices and applications," Prentice Hall of India.
3. Robert W Erickson , "Fundamentals of Power Electronics" , Springer. Second edition-2000
4. Marian K. Kazimierczuk ,"Pulse-Width Modulated DC_DC power converter ", John Wiley & sons Ltd.,2008
5. V. Ramanarayanan, Course Material on Switched Mode Power Conversion, Indian Institute of Science, Bangalore, 2008

23CS125: Professional Elective-IV-C (Stochastic Estimation and Control)

Credits : 3 | Lectures per week : 3

Univ. Exam. Marks : 60 | Sessional Marks : 40

Total Marks : 100

CO 1	Understand the fundamentals of probability theory and random variables.
CO 2	Develop an understanding of stochastic processes and their characteristics.
CO 3	Analyze optimal prediction, filtering, and estimation techniques for discrete linear systems.
CO 4	Analyze optimal estimation techniques for continuous linear systems.
CO 5	Understand stochastic optimal control and optimal smoothing for linear systems.

Program Matrix

COs	**Program Outcomes (POs)**			**PSO1**
	PO1	PO2	PO3	
CO1	2	-	2	2
CO2	2	2	2	2
CO3	3	2	2	2
CO4	3	1	2	2
CO5	3	2	2	2

Subjects

UNIT-I: **12 Lectures**

Elements of Probability Theory: Introduction, Definition of probability and random variables, Probability functions, Expected value and Characteristic function, Independence and correlation, Some Common Distribution methods.

UNIT-II: **12 Lectures**

Elements of the theory of Stochastic process and Development of system models: Concept of a Stochastic Processes, Function Normal or Gaussian Variable, Gaussian Random Process, Stationarity, Ergodicity, Cross correlation Function, Power Spectral Density Function, Cross Spectral Density Function, White Noise.

UNIT-III: **12 Lectures**

Optimal prediction and filtering for discrete linear systems: Introduction, Optimal Estimation for discrete systems, Optimal prediction for discrete linear systems, Optimal filtering for discrete linear systems (Kalman Filtering).

UNIT-IV: **12 Lectures**

Optimal estimation for continuous linear systems: Wiener –hopf Integral Equation, Shapping filter, problem of System Identification using Cauchy-Residue Theorem.

UNIT-V: **12 Lectures**

Stochastic optimal control for continuous linear systems: Introduction, Designing of optimum systems using Configuration fixed, Configuration semi-free, Configuration free.

Optimal Smoothing for discrete linear systems: Linearized Error Propagation, classification of smoothing estimates.

TEXT BOOKS:

1. Stochastic Optimal Linear Estimation and Control, J.S.Meditch, McGraW Hill Book Company
2. Brown, Robert Grover, and Patrick Y. C. Hwang. *Introduction to Random Signals and Applied Kalman Filtering.* New York: John Wiley & Sons
3. Stochastic Estimation and Control, P. Vander Velde, Fall Book Company

23CS 126: Control Systems Simulation Lab

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

CO 1	Analyze and transform transfer functions into signal flow graphs to visually represent system dynamics.
CO 2	Evaluate time domain specifications and apply the Routh-Hurwitz criterion to determine stability of control systems.
CO 3	Assess controllability and observability, and design lag and lead compensators for improved system performance.
CO 4	Apply Ziegler-Nichols PID tuning and pole placement methods to achieve desired control system behavior
CO 5	Convert continuous systems to discrete domains, analyze discrete step responses, and assess stability using the Jury criterion and Lyapunov method.
CO6	Formulate and design control strategies using the Linear Quadratic Regulator approach for optimal system performance.

Program Matrix

COs	**Program Outcomes (POs)**			**PSO1**
	PO1	PO2	PO3	
CO1	2	3	3	2
CO2	2	3	3	2
CO3	3	3	3	2
CO4	3	3	3	2
CO5	3	3	3	2
CO6	3	3	3	

LIST OF EXISTING EXPERIMENTS

S. No.	Experiment Name
1	Conversion of transfer function to signal flow graph
2	Transfer function from block diagram
3	Time domain specifications
4	Routh Hurwitz Criterion
5	Check for stability (Time & Frequency Response)
6	Test for Controllability and Observability
7	Lag and Lead Compensator
8	Z-N PID method
9	Pole placement method
10	Continuous to discrete conversion
11	Discrete step response
12	Jury stability
13	Lyapunov Stability
14	Linear Quadratic Regulator (LQR)