Master of Technology

In

Electrical Engineering
(Signal Processing and Control)

Course Structure & Syllabus

Department of Electrical Engineering

National Institute of Technology Hamirpur

Hamirpur (HP) – 177005, India

Course Structure of M. Tech. Electrical Engineering (Signal Processing and Control)

SEMESTER-I

Sr. No.	Course No.	Subject	Teaching Schedule			Hours/week	Credit
			L	T	P		
1	EE-631	Digital Signal Processing & Applications	4	0	0	4	4
2	EE-632	Probabilistic Methods of Signal and System Analysis	4	0	0	4	4
3	EE-633	Nonlinear Systems	4	0	0	4	4
4	EE-7MN	Programme Elective-I	4	0	0	4	4
5	EE-7MN	Programme Elective-II	4	0	0	4	4
6	EE-634	Control and Computation Lab	0	0	4	4	2
	Total		**20**	**0**	**4**	**24**	**22**

Programme Elective-I & II: List of Programme Electives is given in the Annexure

SEMESTER-II

Sr. No.	Course No.	Subject	Teaching Schedule			Hours/week	Credit
			L	T	P		
1	EE-641	Statistical Signal Analysis	4	0	0	4	4
2	EE-642	Adaptive Signal Processing	4	0	0	4	4
3	EE-643	Optimal Control Theory & Design	4	0	0	4	4
4	EE-7MN	Programme Elective-III	4	0	0	4	4
5	EE-7MN	Programme Elective-IV	4	0	0	4	4
6	EE-644	Signal Processing Lab	0	0	4	4	2
	Total		**20**	**0**	**4**	**24**	**22**

Programme Elective -III & IV: List of Programme Electives is given in the Annexure.

SEMESTER-III

Sr. No.	Course No.	Course Name	Hours/week	Credit
1	EE-800	M.Tech. Dissertation	--	20
	Total		**--**	**20**

SEMESTER-IV

Sr. No.	Course No.	Course Name	Hours/week	Credit
1	EE-800	M.Tech. Dissertation	--	20
	Total		**--**	**20**

Total Credit of the Programme = 84

Annexure
List of Programme Electives

Programme Elective I

EE-711 AI Techniques and Applications
EE-712 Optimization Techniques
EE-713 Genetic Algorithm and Evolutionary Programming

Programme Elective II

EE-731 Digital Image Processing and Pattern recognition
EE-732 Control System Design & Analysis
EE-733 Stochastic Systems
EE-734 Speech Signal Processing

Programme Elective III

EE-741 Advanced Process Control
EE-742 Bio Medical Signal Processing
EE-743 Chaotic System Control & Synchronization

Programme Elective IV

EE-728 Signal Conditioning and Data Acquisition
EE-744 Nonlinear Control Design
EE-745 Microprocessor Based Instrumentation System
EE-746 Linear System Theory

Course Name: Digital Signal Processing and Applications
Course Code: EE-631
Course Type: Core

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about the sampling / reconstruction of signals and their analysis in frequency domain.
- To introduce the fundamental concepts for filter designs, and multi-rate processing.
- To enable the students to understand the efficient algorithms and their use in real time implementation

Course Content

Discrete Time Signals: Sequences; representation of signals on orthogonal basis; Sampling and Reconstruction of signals; Discrete Systems: attributes, Z-Transform, Analysis of LSI systems, Frequency Analysis, Inverse Systems, Discrete Fourier Transform (DFT), Fast Fourier Transform algorithm, Implementation of Discrete Time Systems. Design of FIR Digital Filters: Window method, Park-McClellan's method. Design of IIR Digital Filters: Butterworth, Chebyshev and Elliptic Approximations; Lowpass, Bandpass, Band-stop and High pass filters. Effect of finite register length. Fundamental of Multi-rate System: Basic multi-rate operations, interconnection of building blocks, poly-phase representation, multistage implementation, applications of multi-rate systems, filter banks. Introduction to Wavelet Transform: Short-time Fourier transform, Wavelet transform.

Course Outcomes

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

CO1: Understand the importance of discrete time signals

CO2: Algorithms for efficiently computing the DFT are called Fast Fourier Transform (FFT) methods

CO3: Design of FIR and IIR filter

CO4: Multi-rate signal processing and concept of decimators and interpolators.

CO5: STFT and Wavelet transforms and their role in DSP.

Books and References

1 Discrete Time Signal Processing by A.V. Oppenheim and Schafer, Prentice Hall.
2 Digital Signal Processing: Principle, Algorithms and Applications by John G. Proakis and D.G. Manolakis, , Prentice Hall.
3 Theory and Application of Digital Signal Processing by L. R. Rabiner and B. Gold, Prentice Hall.
4 Introduction to Digital Signal Processing by J.R. Johnson, Prentice Hall.
5 Digital Signal Processing by D. J. DeFatta, J. G. Lucas and W. S. Hodgkiss, J Wiley and Sons, Singapore.

Course Name: Probabilistic Methods of Signal and System Analysis
Course Code: EE-632
Course Type: Core

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about the probability, random variables and distribution functions of signal processing and their analysis in frequency domain.
- To introduce the fundamental concepts of generating functions, random processes and their applications.
- To enable the students to understand the efficient distributions and their use in real time implementation.

Course Content

Introduction to Probability: Random experiments and events. Definition of probability, relative frequency approach. Elementary set theory. Axiomatic approach. Conditional probability. Probability of repeated trials and combined experiments. Random Variables: Concept of random variable, distribution, and density functions. Mean values and moments. Gaussian random variable. Functions of one random variable and their distribution, and density functions. Conditional distribution and density functions. Several Random Variables: Joint (bivariate) distributions, one function of two random variables, two function of two random variables, joint moments of two random variables, joint characteristic functions, conditional density and statistical independence. Correlation between random variables. Characteristic functions. Random processes: General concepts and classifications correlation functions and their properties, spectral density and its properties. White noise Response of linear systems to random inputs: Analysis in the time domain, mean, mean-square value and correlation functions of system output for random input. Analysis in frequency domain system with stochastic inputs, power spectral and cross –spectral densities.

Course Outcomes

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

CO1: Understand the importance of probability and random variables.

CO2: Identify the distribution with their properties.

CO3: Gain the knowledge of random processes, spectrum density.

Books and References

1. Probability, Random Variables and Stochastic Processes by Athanasios Papoulis, McGraw-Hill.
2. Probability, Random Variables and Stochastic Processes by Hwei P. HSU Schaum' Series, Tata McGraw-Hill Publishing company Ltd. New Delhi.
3. A First Course in Probability by Sheldon Ross, Pearson Education.
4. Modern Probability Theory-An Introductory Text Book by B. R. BhattNew Age International Pvt. Ltd, New Delhi.
5. A Course in Probability Theory by Kai Lai Chung, Academic Press.
6. Probability, Random Processes and Ergodic Properties by Robert M. Gray, Springer-Verlag, New York.
7. An Introduction to Probability Theory and its Applications by W. Feller Vol. I, Wiley Eastern Limited, New Delhi.
8. Probabilistic Methods of Signal and System Analysis by George R. Cooper and C.D. McGillem, Oxford University Press, New Delhi.
9. Probability and Statistics with Reliability and Queuing and Computer Science Applications by K. S. Trivedi, Indian Edition, John Wiley & Sons Inc. UK.

Course Name: Nonlinear Systems
Course Code: EE-633
Course Type: Core

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about developing state space models from differential/transfer function-based descriptions of linear systems.
- To enable the students to learn designing simple feedback controller for linear dynamical systems.
- To introduce the fundamental learning about typical behaviors of nonlinear systems and their stability analysis.
- To develop basic understanding about design of stabilization and tracking control for nonlinear systems.

Course Content

Review of state variable analysis, state space representation of systems, block diagram for state equation, Transfer function decomposition, direct, parallel and cascade decomposition, solution of state equations, concept of controllability and observability, pole placement by feedback, controller design by Ackermann method; Characteristic behavior of Non Linear Systems, difference between linear and nonlinear systems, different nonlinearities, Common nonlinear system behaviors like multiple equilibrium points, limit cycle etc.; Non-linear systems analysis, phase plane method, singular points, construction of phase trajectories, phase plane analysis of linear and nonlinear systems, concepts of describing function method, stability analysis using describing function method; Lyapunov Stability Theory, concept of stability, stability theorems, Lyapunov functions for nonlinear and linear systems, Invariant set theorem, Krasovskii method, concept of stability of non-autonomous systems, Barbalat Lemma, Lyapunov analysis of non-autonomous systems; Introduction to nonlinear control system Design, nonlinear control problems, stabilization and tracking problems, specifying desired behavior, issues in constructing nonlinear controllers, controller design based on feedback linearization, input-state and input-output linearization.

Course Outcomes

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

CO1: Develop state space models for linear and nonlinear systems.

CO2: Design simple control schemes for linear dynamical systems.

CO3: Analyse the stability of linear and nonlinear systems using Lyapunov method, phase plane and describing function method etc.

CO4: Apply feedback linearization to address stabilization and tracking problems.

Books and References

1. Applied Nonlinear Control by J. J. E. Slotine & W. Li, Prentice Hall, Englewood Cliffs New Jersey.
2. Control System Engineering by I. J. Nagrath & M. Gopal, New Age International New Delhi.
3. Nonlinear Systems by Hassan K. Khalil, Prentice Hall, Englewood Cliffs New Jersey.
4. Digital control and state variable methods by M.Gopal, Tata McGraw Hill, New Delhi.

Course Name: AI Techniques and Applications **Course Code: EE-711** **Course Type: Programme Elective-I**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To impart knowledge about the application of artificial intelligence techniques in electrical engineering.
- To introduce the fundamental concepts relevant to fuzzy logic, artificial neural network, genetic algorithm, Evolutionary techniques and Hybrid systems.
- This activity aims to get students thinking critically about what specialty makes humans intelligent, and how computer scientists are designing computers to act smartly or human like.

Course Content

Artificial Intelligence: Definition, problem solving methods, searching techniques, knowledge representation, reasoning methods, predicate logic, predicate calculus, multi-value logic. Fuzzy Logic: Concepts, fuzzy relations, membership functions, matrix representation, de-fuzzification methods. Artificial Neural Network: Introduction, multi-layer feed forward networks, back propagation algorithms, radial basis function and recurrent networks. Evolutionary Techniques: Introduction and concepts of genetic algorithms and evolutionary programming. Hybrid Systems: Introduction and Algorithms for Neuro-Fuzzy, Neuro-Genetic, Genetic-Fuzzy systems.

Course Outcomes

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

CO1: Identify different searching techniques, constraint satisfaction problem and example.

CO2: Able to apply these techniques in different field, which involve perception, reasoning and learning.

CO3: Analyze and design a real world problem for implementation and understand the dynamic behavior of a system.

CO4: Assess the results obtained by ANN, Genetic algorithm and fuzzy systems.

Books and References

1. Artificial Intelligence and Intelligent Systems by NP Padhy, Oxford University Press
2. Neural Networks, Fuzzy Logic and Genetic Algorithm Synthesis and applications by Rajasekaran S. and Pai G.A.V., PHI New Delhi.
3. Neural Fuzzy Systems by Lin C. and Lee G., Prentice Hall International Inc.
4. Genetic Algorithms in Search Optimization & Machine Learning by Goldberg D.E., Addition Wesley Co., New York.
5. Neural Networks & Fuzzy Systems A dynamical Systems Approach to Machine Intelligence by Kosko B., Prentice Hall of India.

Course Name: Optimization Techniques
Course Code: EE-712
Course Type: Programme Elective-I

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about the principles of optimization techniques.
- To introduce the fundamental concepts relevant to classical optimization methods, linear programming, nonlinear programming and dynamic programming.
- To enable the students to understand the factors that cause the different optimization methods to provide different solutions for the same mathematical problem.

Course Content

Introduction to optimization; Objective function; Constraints and Constraint surface; Classification of optimization problems; Optimization techniques – classical and advanced techniques, linear programming (LP) problem; Elementary operations; Graphical method for two variable optimization problem; Examples; Motivation of simplex method, Simplex algorithm and construction of simplex tableau; Simplex criterion; Minimization versus maximization problems; simplex method with artificial variables; Optimization using Calculus**,** Stationary points - maxima, minima and saddle points; Global Optimum; Convexity and concavity of functions of one and two variables; Optimization of function of one variable and multiple variables; Gradient vectors; Examples; Optimization of function of multiple variables subject to equality constraints; Lagrangian function; Optimization of function of multiple variables subject to inequality constraints; Hessian matrix formulation; Eigen values; Kuhn-Tucker Conditions; Examples, nonlinear programming, one dimensional minimization methods, unconstrained optimization methods, direct search methods, descent methods, 2^{nd} order methods, constrained optimization, indirect methods, exterior penalty function, interior penalty function, geometric view point, augmented lagrange multiplier , kuhn tucker conditions, introduction to dynamic programming, sequential optimization; representation of multistage decision process; types of multistage decision problems; concept of sub optimization and the principle of optimality; Recursive equations – Forward and backward recursions; Computational procedure in dynamic programming (DP); Discrete versus continuous dynamic programming; curse of dimensionality in DP, example.

Course Outcomes

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

CO1: Identify different types of optimization techniques and problems.

CO2: Describe techniques like calculus based classical optimization, linear programming, nonlinear programming, dynamic programming.

CO3: Apply principles and techniques described in CO2 to solve sample mathematical and practical optimization problems.

CO4: Assess the results obtained by applying optimization techniques to solve mathematical programming problems.

Books and References

1. Engineering Optimization: Theory and Practice by S. S. Rao, New Age International (P) Ltd.,New Delhi.
2. Numerical optimization with applications by Suresh Chandera, Jaydeva, and Aparna Mehta Publisher: Narosa.
3. An Introduction to optimization by Edvin K. P. Chong, and Stanislaw H. Zak, Publisher: John Wiley.
4. Optimization theory and practice by Mohan C. Joshi and Kannan M Moudgalya, Publisher: Narosa.

Course Name: Genetic Algorithms and Evolutionary Programming
Course Code: EE-713
Course Type: Programme Elective-I

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about related with Genetic algorithm and Evolutionary programming.
- To introduce the fundamental concepts relevant to GA operators, creation of offspring etc.
- To enable the students to understand the factors related with application and fundamental of GA and EP.

Course Content

Introduction, Basic concepts and definitions, artificial intelligence, genetic algorithms (GAs), evolutionary programming (EP), Genetic algorithm, Coding, fitness function, Calculation of the number of bit required for a variable, GAs operators, crossover and mutation, roulette wheel method for selection process, cumulative probabilities, Basic flow chart, GAs for optimization detail steps, Similarities between GAs and traditional methods, Differences between GAs and traditional methods, Evolutionary programming, Initialization, Creation of offspring, Competition and selection, Gaussian random numbers, standard deviation, Difference between GAs and EP, basic algorithm, step by step procedure of evolutionary programming for optimization. Applications of GAs for economic power dispatch and optimal power flow, applications of EP for economic power dispatches and optimal powers flow.

Course Outcomes

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

CO1: Identify various concepts of Genetic algorithm and Evolutionary programming.

CO2: Describe important concepts related with optimization with GA and EP.

CO3: Apply principal to explain various problems related with problems described in CO2.

CO4: Assess the results obtained by solving above problems.

Books and References

1. Genetic Algorithms, Data Structures and Evolution Programs by Z. Michalewicz, Berlin: Springer-Verlag.
2. Genetic Algorithms in search, Optimization and Machine Learning by D.E. Goldberg, Addison-Wesley.
3. Genetic Algorithms for VLSI Design, Layout & Test Automation by Pinaki Mazumder and Elizabeth M. Rudnick, Prentice Hall PTR.

Course Name: Digital Image Processing & Pattern Recognition
Course Code: EE-731
Course Type: Programme Elective-II

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To introduce the concepts of digital images, human visual system, EM spectrum, color models.
- To discuss transforms and principal mathematical tools required for processing of digital images.
- To develop background for filtering of digital images in spatial and transform domain.
- To describe techniques related to Image segmentation and Image compression.
- To introduce the Pattern recognition methods and their application for image processing.

Course Content

Introduction Digital image representation, Fundamental steps in image processing, Elements of Digital Image processing systems, Elements of visual perception, Image model, Sampling and quantization, Relationship between pixels, imaging geometry, Color Models, Color Transforms. Image Enhancement, Enhancement by point processing, Sample intensity transformation, Histogram processing, Image subtraction, Image averaging, Spatial filtering, Smoothing filters, Sharpening filters, Frequency domain: Low-Pass, High-Pass, Homomorphic filtering. Spatially dependent transform template and convolution, Window operations, 2-Dimensional geometric transformations. Wavelets and Multiresolution Processing: Image pyramids, Subband coding, Haar transform, Series expansion, Scaling functions, Wavelet functions, Discrete wavelet transforms in one-dimension, Fast wavelet transform, Wavelet transforms in two dimensions. Image Segmentation Detection of discontinuities, Edge linking and boundary detection, Thresholding, Region oriented segmentation, use of motion in segmentation, Spatial techniques, Frequency domain techniques, Image Segmentation Based on color. Image Compression Coding redundancy, Inter-pixel redundancy, fidelity criteria, Image compression models, Error-free compression, Variable length coding, Bit-plane coding, Loss-less predicative coding, Lossy compression, Image compression standards, Real-Time image transmission, JPEG and MPEG. Pattern Recognition Classification and description, Structure of a pattern recognition system, feature extraction, Classifiers, Decision regions and boundaries, discriminant functions, Supervised and Unsupervised learning, PR-Approaches.

Course Outcomes

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

CO1: Understand the principle of Digital image formation and concept of intensity & spatial resolution.

CO2: Enhance digital images using spatial and frequency domain approaches.

CO3: Understand the basic mathematics related to spatial and transform domain image compression approaches.

CO4: Implement basic feature extraction approaches and utilize them for Pattern recognition problems.

Books and References

1. Digital Image Processing by R. Gonzalez and R. E. Woods, Prentice Hall of India.
2. Image Processing, Analysis, and Machine Vision by M. Sonka, V. Hlavac, R. Boyle, Cengage Learning.
3. Introductory Computer Vision and Image Procession by Andrian Low, McGraw Hill Co.
4. Pattern Recognition-Statistical, Structural and Neural approach by Robert Scholkoff, John Willey & Sons.
5. Digital Image Processing by W.K. Pratt, McGraw Hill.
6. Fundamentals of Image Processing by A.K. Jain, Pearson Education.

Course Name: Control System Design and Analysis
Course Code: EE-732
Course Type: Programme Elective-II

Contact Hours/Week: **4L**
Course Credits: **04**

Course Objectives

- To impart knowledge about conventional/modern control system design and analysis tools, such as internal model control, state feedback control, and observers etc.
- To introduce the fundamental concepts of linear system theory, including internal stability, realizations, controllability and observability.
- To enable the students to understand the case studies of successful modern control implementations.

Course Content

Introduction: Review of time and frequency domain analysis techniques for control systems, stability analysis, introduction to controller configurations and design. Industrial Controllers: Introduction, industrial automatic controllers, ON/OFF controller, P, PI, PD, PID controllers, tuning rules for PID controllers, one degree of freedom and two degree of freedom control, various design considerations. Root Locus Design: Cascade compensator design for improving steady state response and transient response, lag, lead, lag-lead compensators design. Frequency domain design of control Systems: Introduction, lead, lag, lead-lag compensation, comparison of different compensation techniques, rate feedback compensation design. State Space Design of Systems: Analysis of control systems in state space, solution of the state equation, controllability and observability, pole placement method, state feedback matrix, state observers, minimum order observers. Liapunov Stability Analysis: LTI System analysis using Liapunov method, Model Reference Control, Quadratic optimal control.

Course Outcomes

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

CO1: Understanding to apply the concepts of system response (including transients and steady-state) and of system stability.

CO2: An idea to apply the principles of feedback control in engineering systems, to design control systems for steady-state tracking of reference inputs.

CO3: To apply graphical design techniques (e.g., root locus, Nyquist plots, Bode plots) to control systems design.

CO4: Understanding of the fundamental concept of state space representation of dynamical systems, Iiapunov stability analysis.

Books and References

1. Modern Control Engineering by Ogata K., Prentice Hall of India Pvt. Ltd., New Delhi, India.
2. Modern Control Design by Tewari A., John Wiley and Sons Ltd., England.
3. Discrete time Control Systems by K. Ogata, Prentice Hall International.
4. Control System Engineering by Nagrath I. J., Gopal M., Wiley Eastern Limited.
5. Digital Control Systems by B. C. Kuo, Oxford University Press.

Course Name: Stochastic Systems
Course Code: EE-733
Course Type: Programme Elective-II

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about the random phenonmena.
- To introduce the concepts of statistical estimators.
- To enable the students to understand convergence theorem and markov proceses.

Course Content

Review of probability: random variables, random processes, Estimation and detection with random sequences; BAYES, MMSE, MAP, ML Schemes, Linear stochastic dynamical Systems, Martingale Convergence theorem: Ergodic Theory; Measure preserving transformations, stationary processes, mixing conditions, ergodic Theorems, Shannon – Millan- Breiman Theorem Markov Chains: Continuous time processes, separability, continuity, measurability, stochastic integral.

Course Outcomes

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

CO1: Understanding of basic concept of stochastic systems.
CO2: Describe the various approaches for statistical estimation.
CO3: Derivation of various convergence theorems and implementation of statistical estimation methods.
CO4: Performance Comparison of different statistical estimation methods.
CO5: Model the practical problems using the concept of the statistical theory.

Books and References

1. Random Variables and Stochastic processes by Papoulis Simon, Probability, McGraw Hill, New York.
2. Stochastic Optimal Linear Estimation and control by J. E. Meditch, McGraw Hill, New York.
3. Probability and Stochastic processes for Engineers by C. W. Helstorm, McMillan, New York.
4. Optimal and Adaptive Signal Processing by Peter M Clarkson, CRC Press London.
5. Advanced Digital Signal Processing and Noise Reduction by Saeed V Vaseghi, John Wiley & Son..
6. Statistical and Adaptive Signal Processing by D G Manloakis, V K Ingle and S M Kogan, McGraw Hill.

Course Name: Speech Signal Processing
Course Code: EE-734
Course Type: Programme Elective-II

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To familiarize the student with the mechanism of speech production, physics of sound and modeling of speech signal.
- To explain the algorithms for speech analysis and speech synthesis.
- To describe techniques related to speech coding.
- To discuss applications like speaker recognition, speech recognition etc.

Course Content

Models for Speech Signal: Production & Classification of Speech Sounds, Acoustics of Speech Production, speech perception. Speech Analysis: Time and frequency domain techniques for pitch and formant estimation, cepstral and LPC analysis. Speech Synthesis: Articulatory, formant, and LPC synthesis, voice response and text-to-speech systems. Applications: Data compression, vocoders, speech enhancement, speech recognition, speaker recognition, aids for the speech and hearing impairments.

Course Outcomes

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

CO1: Derive the expression for the digital models related to speech production.

CO2: Understand the algorithms and techniques used for speech analysis and synthesis.

CO3: Extract time and frequency domain features from given speech signals.

CO4: Comprehend the utility of different algorithms for applications like speaker and speech recognition.

Books and References

1. Digital Processing of Speech Signals by L.R. Rabiner & R.W Schafer., Prentice Hall Inc.
2. Speech Communication, Human and Machine by D. O'Shaughnessy, Addison-Wesley.
3. Discrete-Time Speech Signal Processing: Principles and Practice by Thomas F. Quatieri , Prentice Hall, Signal Processing Series.
4. Discrete-Time Processing of Speech Signals by J. Deller, J. Proakis, and J. Hansen, Macmillan.

Course Name: Control & Computation Lab
Course Code: EE-634

Contact Hours/Week: **4P** Course Credits: **02**

Course Objectives

- To analyze the performance of basic control components experimentally.
- To study performance characteristics of LTI systems using basic control mechanisms i.e compensators and PID controllers.
- To learn about process control challenges and to execute control strategy to meet out desired performance.
- To study complex control mechanisms involving MIMO systems and coupled systems.

List of Experiments

1. Study of two-phase AC servo motor and draw its speed torque characteristics.
2. To study synchro transmitter–receiver pair and its operation as an error detector.
3. To study speed control and reversal of stepper motor using microprocessor.
4. To study magnetic amplifier and plot the control current versus load current characteristics in the Series connection, Parallel connection and Self-saturation mode.
5. To study magnetic levitation system and to perform tracking control using PI Control.
6. To study magnetic levitation system and to perform tracking control using PID Control.
7. To study modeling and control of non-linear MIMO systems using Twin rotor helicopter model.
8. To study real time Cart-pendulum arrangement based Inverted pendulum stabilization with real time swing control using Digital Pendulum set up.
9. To study feedback control using rotary inverted pendulum module
10. To study real-time control of a non-linear and unstable ball plate process set up and to analyze real-time PID control of ball position
11. To study real-time control of a non-linear and unstable ball plate process set up and to analyze control of real-time trajectory tracking with ball
12. To study simulation and real time model for single tank level control using coupled tank apparatus.
13. To study simulation and real time models for level control in parallel tanks using couple tank apparatus.
14. To study PI & PID based control of water level using Process Control Trainer.
15. To study voltage sensitive bridge and to analyze its sensitivity and linearity.
16. To design, implement and study the effects of different cascade compensation networks for a given system.
17. To study the Digital control system and to Implement digital PID control for a modeled process
18. To study relay as nonlinear element and effect of dead-zone and hysteresis on the controlled process
19. MATLAB based State Feedback (Pole Placement) controller design for a given LTI system.
20. MATLAB based State Observer design for a given LTI system.
21. MATLAB based implementation of Observer based control scheme for a given LTI system
22. PID Control gain tuning for a given control system with desirable time domain performance attributes using MATLAB

Note: *The concerned Course Coordinator will prepare the actual list of experiments/problems at the start of semester based on above generic list.*

Course Outcomes

CO1: Understand the characteristic behavior of control components and their use in industrial applications.
CO2: Implement PID control strategy to achieve stabilization and tracking behavior in linear and nonlinear systems.
CO3: Understand the nonlinear and unstable processes and the associated control challenges.

Course Name: Statistical Signal Analysis
Course Code: EE-641
Course Type: Core

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To develop ability to process discrete random signals
- To study the algorithms for modeling of stochastic signals.
- To study the basic classical and Bayesian estimation techniques
- To familiarize with non-parametric and parametric spectrum estimation techniques.

Course Content

Introduction: Signal Processing methods, Review of Probability Theory, Random Variables and Stochastic Processes. Random Signal Analysis: Discrete random signals, Spectral representation of discrete random signals, filtering random processes, Random signal models AR, MA and ARMA. Power spectrum and phase of the signal generating system, Least squares method, Padé approximation, Prony's method, finite data records, stochastic models, Levinson-Durbin recursion; Schur recursion; Levinson recursion. Spectrum Estimation: Nonparametric methods, minimum-variance spectrum estimation, maximum entropy method, parametric methods, frequency estimation, principal components spectrum estimation. Estimation Theory: Estimation of moments, classical and Bayesian estimation. MAP, ML, MMSE, and MAVE estimators for model parameters and signal. Cramer-Rao Bound on the minimum estimator variance. Introduction to Hidden Markov Models, Noise and Distortion.

Course Outcomes

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

CO1: Apply the principles of random processes for analysis of linear systems.

CO2: Model random signals and appreciate its utility in signal interpolation, signal prediction and signal compression.

CO3: Implement estimation techniques on signal processing problems and acquire ability to estimate parameters using them.

CO4: Understand the non-parametric and parametric spectrum estimation techniques.

Books and References

1. Probability, Random Variables and Stochastic Processes by A. Papoulis, McGraw Hill.
2. Statistical Digital Signal Processing and Modelling by Monson H. Hayes, John Wiley & Sons Inc.
3. Fundamentals of Statistical Signal Processing, Volume I: Estimation Theory by Steven M. Kay, Prentice Hall, USA.
4. Advanced Digital Signal Processing and Noise Reduction by Saeed V. Vaseghi, John Wiley & Sons, Ltd, Singapore.
5. Statistical and Adaptive Signal Processing by Dimitris G. Manolakis, Vinay K. Ingle and Stephen M. Kogan, McGraw Hill.
6. Detection, Estimation and Modulation Theory, Part 1 and 2 by Harry L. Van Trees, John Wiley & Sons Inc.
7. Optimal and Adaptive Signal Processing by Peter M. Clarkson, CRC Press London.

Course Name: Adaptive Signal Processing
Course Code: EE-642
Course Type: Core

Contact Hours/Week: **4L** | Course Credits: **04**

Course Objectives

- To impart knowledge about the adaptive filtering.
- To introduce the concepts of statistical optimal Wiener solution and deriving various gradient search based adaptive algorithm for different objective functions.
- To enable the students to understand adaptive filter based various linear predictors, their structures and applications.

Course Content

Introduction to Adaptive Signal Processing: General properties Filtering, prediction and smoothing. Applications in Communications: Equalization Echo cancellation Noise cancellation, switched communication systems. Optimal Signal Processing: Principles of orthogonality, minimum square error, Wiener Hopf equations, state space model, innovations process, Kalman filter equations. Gradient Search Algorithms: Steepest descent adaptation algorithms, effect of eigen-value spread on stability and rate of convergence, stochastic gradient descent using Least Mean Squares (LMS) algorithms, transient and steady state properties including convergence rate and mis-adjustment, least square estimation, normal equations, Recursive Least Squares (RLS) algorithms, relationship between RLS and Kalman filters. Linear Prediction: Forward Linear Prediction, Backward Linear Prediction, Levinson-Durbin Algorithm, Properties of the Prediction Error Filter, Joint Process Estimator, Adaptive Lattice Filter, Coders using linear Prediction Applications in Communications: Introduction to Fast Recursive Algorithms for Equalization Adaptive linear prediction, lattice filtering for RLS. Other Applications Echo cancellation in two-wire systems, Noise cancellation

Course Outcomes

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

CO1: Understanding of basic concept of adaptive filter theory
CO2: Describe the basic components/specifications of adaptive filter
CO3: Derivation and implementation of various gradient search adaptive algorithms.
CO4: Performance Comparison of different adaptive algorithms.
CO5: Application of adaptive filtering in linear prediction, channel equalization, echo cancellation and noise cancellation in communication system.

Books and References

1. Adaptive Filter Theory by Simon Haykin, Pearson Education Inc.
2. Digital Signal and Image Processing by Tamal K Bose, John Wiley & Sons Inc,USA.
3. Adaptive Filtering Algorithms and Practical Implementation by Paulo S R Diniz, Kluwer Academic Publisher.
4. Optimal and Adaptive Signal Processing by Peter M Clarkson, CRC Press London.
5. Adaptive Signal Processing by Bernard Widrow and Sumuel D Sterns, Addison Wesley Pvt Ltd Delhi.
6. Advanced Digital Signal Processing and Noise Reduction by Saeed V Vaseghi, John Wiley & Sons.
7. Statistical and Adaptive Signal Processing by D G Manloakis, V K Ingle and S M Kogan, McGraw Hill.

Course Name: Optimal Control Theory and Design
Course Code: EE-643
Course Type: Core

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To develop basic understanding about various optimal control problems existing in practice.
- To enable the students to formulate optimal control problems for continuous systems with and without constraints.
- To introduce the calculus of variation-based approach to address continuous-time and discrete-time optimization problems.
- To impart basic knowledge about designing state observers and optimal observers.

Course Content

Introduction and classification of optimal control problems, different optimal control problems, Performance indices for optimal control; Calculus of variation, Optimization without constraints, Euler-Lagrange equation for different two point boundary value problems (TPBVP), Hamiltonian Formalism, Hamilton-Jacobi equation; Linear Quadratic Optimal Control, Finite and infinite horizon problems for continuous time systems, formulation of regulator and tracking problem, Regulation problem with prescribed degree of stability, output regulator and tracking problem, Formulation of LQR problem for discrete time systems; Pontragin Principle and Dynamic Programming, Constrained System, Pontragin Minimum Principle, Multistage decision process in continuous time, H-J-B principle, dynamic programming based control problem formulation for discrete systems; Optimal observers and Controllers, Introduction to continuous and digital Observers, State observers, separation principle, optimal observers, Kalman Filter, LQR/LQG controllers, State observer-state feedback configuration, disturbance rejection, tracking performance.

Course Outcomes

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

CO1: Identify different optimal control problems in real practice.

CO2: Develop analytical solutions for optimal control problems with and without constraints.

CO3: Analyse the class of optimal control problems with quadratic objective function in continuous and discrete setting.

CO4: Develop mathematical structure for observers/estimators for linear systems.

Books and References

1. Optimal Control Systems by D.S. Naidu, New CRC Press, USA.
2. Modern Control System Theory by M Gopal, Wiley Eastern, New Delhi.
3. Optimum Systems Control by A.P. Sage & C.C White, Englewood Cliff New Jersey, Prentice Hall.
4. Optimal Control Theory by D.E Kirk, Englewood Cliff New Jersey, Prentice Hall.

Course Name: Advance Process Control
Course Code: EE-741
Course Type: Programme Elective-III

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about the different process dynamics in Process industries and different control schemes generally used to get best output.
- To introduce the fundamental concepts of controller design in various loops and also optimization of their parameters.
- It also makes students aware of various analysis and design methods for multivariable systems. In addition, the subject also introduces about discrete state process control and advanced control schemes such as Internal Model Control (IMC) and Model Predictive Control for industrial process.

Course Content

Introduction to process control, review of general concepts of system simulation and modeling, Process dynamics of fluid flow, heat transfer systems and chemical processes, dynamical behavior of simple and complicated processes with time delay, development of process model from empirical data, fitting first and second order models, development of discrete dynamical models, ratio control and feedforward controllers, PID controller design, tuning and troubleshooting, Enhanced single loop control strategies, cascade control, time delay compensation and inferential control, Digital PID controllers and their tuning, multi-loop and multivariable control, pairing of controlled and manipulated variables, tuning of multi-loop PID controller, formulation and solution of real time optimization problem, unconstrained and constrained optimization, Internal Model Control (IMC), Model Predictive Control (MPC), Prediction of MIMO models, MPC calculations and implementation, Some typical applications of process modeling and control. Introduction of PLC.

Course Outcomes

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

CO1: The students will be able to handle any kind of process by framing it in block diagram, mathematical model and different process variables.

CO2: The students will be able to handle different types of controller like PID, IMC and MPC.

CO3: The students will be able to implement different control schemes to various processes.

CO4: The students will be able to PLC.

CO5: The students will be able to understand industrial process with an example.

Books and References

1. Process Systems Analysis & Control by Donald Dale E. Seborg, Thomas F. Edgar, Duncan A. Mellichamp, Francis J. Doyle, John Wiley & Sons.
2. Process Dynamics & Control by Donald R. Coughanowr. Mc Graw – Hill International.
3. Design of feedback Control System by Stefani, Savant, Shahian, Hostetter- Oxford University Press.
4. Modern Control System Theory by Gopal M., Wiley Eastern Limited.

Course Name: Biomedical Signal Processing
Course Code: EE-742
Course Type: Programme Elective-III

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To study the origin and process of acquisition of principal bioelectric signals like ECG, EEG, EMG etc.
- To understand the background material required for processing of the biomedical signals.
- To understand the utility of biomedical signals for disease diagnosis like ECG for Cardiovascular diseases and EEG for sleep disorders.
- To explore the utility of bioelectrical signals for developing other application.

Course Content

Introduction: Genesis and significance of bioelectric potentials, ECG, EEG, EMG and their monitoring and measurement, spectral analysis, digital and analog filtering, correlation and estimation techniques, AR/ARMA models, adaptive filters. ECG: Pre-processing, measurements of amplitude and time intervals, classification, QRS detection, ST segment analysis, baseline wander removal, waveform recognition, morphological studies and rhythm analysis, automated diagnosis based on decision theory ECT compression, evoked potential estimation. EEG: Evoked responses, epilepsy detection, spike detection, averaging techniques, removal of artifacts by averaging and adaptive algorithms, pattern recognition of alpha, beta, theta and delta waves in EEG waves, sleep stages. EMG: Wave pattern studies, biofeedback, zero crossing, integrated EMG, time frequency methods, and wavelets in biomedical signal processing.

Course Outcomes

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

CO1: Understand the acquisition methods for collecting ECG, EEG and EMG signals.

CO2: Develop mathematical models for analysis of biomedical signals.

CO3: Identify the characteristic points in an ECG waveform and understand their relevance.

CO4: Understand the EEG and EMG signal analysis and apply them to develop practical applications like BCI, prosthetic limbs.

Books and References

1. Biomedical Signal Analysis by R.M. Rangayyan, Wiley.
2. Biomedical Signal Processing: Principles and techniques by D.C. Reddy, Tata McGraw Hill, New Delhi.
3. Biomedical Signal Processing by Willis J Tompkins, Prentice Hall.
4. Bioelectrical Signal Processing in Cardiac & Neurological Applications by L. Sörnmo, Elsevier

Course Name: Chaotic System Control & Synchronization
Course Code: EE-743
Course Type: Programme Elective-III

Contact Hours/Week: **4L**
Course Credits: **04**

Course Objectives

- To impart knowledge about chaotic systems.
- To introduce the fundamental concepts relevant to nonlinear systems and their control strategies.
- To enable the students to understand the concept of synchronization of chaotic systems.

Course Content

Introduction: chaos control-in a broader sense, why chaos control, some distinct features of chaos control, nonlinear dynamical systems, limit sets and attractors, Poincare maps, center manifold theory, chaos in nonlinear systems, bifurcations, paradigms of chaos symmetry, self-similarity and stabilities. Parameter-Dependent approaches to Chaos Control: Periodic parametric forcing, parametrically forced oscillators, Microscopic parametric variation, controlling chaos to higher-periodic orbits, controlling transient chaos, some applications of parameter control. Open-loop Strategies for chaos control: chaos control via external forcing, entrainment and migration controls. Engineering feedback control: Chaos in feedback control systems, Engineering Control Using Feedback, Feedback control of chaos, controlling chaos via Lyapunov Methods. Chaos Synchronization: what is synchronization, synchronization based on system decomposition, stability analysis for chaos synchronization, chaos synchronization via feedback, synchronization of identical subsystems, adaptive synchronization, chaos synchronization with observer, generalized synchronization, phase synchronization, synchronization via the OLC methods, synchronization by contraction mappings, communication based on chaos synchronization, robustness of chaos synchronization, dead-beat synchronization for communication, implementation of chaos synchronization based communication.

Course Outcomes

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

CO1: Differentiate chaotic systems from common nonlinear systems.
CO2: To apply the concepts of state space analysis for the description of chaotic systems.
CO3: Apply Lyapunov stability analysis to stabilize and synchronize chaotic systems.

Books and References

1. From Chaos to order by Guanrong Chen & Xiaoning Dong, World Scientific.
2. Robust Synchronization of Chaotic Systems via Feedback by Ricardo Femat, Gualberto Solis-Perales, Springer.
3. Applied Nonlinear control by Jean-Jacques E. Slotine, Prentice Hall.

Course Name: Signal Conditioning & Data Acquisition
Course Code: EE-728
Course Type: Programme Elective-IV

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about the signal conditioning
- To introduce the concepts of analog to digital conversion and vice versa and implementation of conditioning circuits
- To enable the students to understand data acquisition systems and telemetry.

Course Content

Signal Conditioning: Introduction, amplification, instrumentation amplifies, Optical amplifiers, A.C.& D.C. amplifiers, Operational amplifier specifications, operational amplifier circuits in instrumentation, Adder, inverter, subtractor, integrator, differentiator, logarithmic converter, Differential amplifier, Modulator-Demodulators, filters, types of filters, low pass, band pass, bridges, current sensitive bridge circuit, Voltage sensitive bridge. Clipping and clamping circuits. A/D & D/A Conversion Techniques: Resolution and Quantization, Aperture time, Sampling D/A Converters, A/D conversion techniques- successive approximation, resistor method, voltage to time A/D converter, Voltage to frequency converter techniques. Dual flow integration technique, Sample and hold circuit. Introduction to Data Acquisition System: Instrumentation systems, types of instrumentation systems, components of an Analog-Data-acquisition system, uses of data acquisition system, use of recorders in digital system, Digital recording systems, input conditioning equipment. Digitizer, Multiplexer (TDM, FDM). Land line telemetry, R F telemetry. Transmission channels. Modulation methods. Harmonic Analysis of Periodic Signals: Fundamentals of Fourier analysis, Practical harmonic analysis using a wattmeter.

Course Outcomes

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

CO1: Understanding of basic concept of signal conditioning and data acquisition
CO2: Describe the basic circuits used in realizing the signal conditioning
CO3: Implementation of analog to digital conversion and signal conditioning circuits.
CO4: Performance Comparison of different data telemetry schemes.
CO5: Application of signal conditioning methods and data acquisition systems to practical problems

Books and References

1. Measurement systems- Application and Design by E.O. Doebelin, TATA Mc Graw Hill.
2. Electronic measurement and instrumentation by Oliver & Cage, McGraw Hill.
3. Microprocessors & Interfacing by Douglas V, Tata McGraw Hill.
4. Operational amplifiers and linear Integrated circuits by R.F. Coughlin & Driscoll, PHI, New Delhi.
5. Microprocessors with Applications in process Control by S.I. Ahson, Tata McGraw Hill New Delhi.
6. Electrical Measurements: Fundamentals, Concepts, Applications by Martin U Reissland, New Age International Publishers.

Course Name: Nonlinear Control Design
Course Code: EE-744
Course Type: Programme Elective-IV

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart comprehensive knowledge about nonlinear dynamical systems.
- To enable students to design stabilizing and tracking controllers for different class of nonlinear systems.
- To introduce the robust control strategies like SMC to develop controllers for systems working in uncertain environment.
- To introduce the concept of online parameter estimation of uncertain nonlinear systems using adaptive control.

Course Content

Introduction, review of nonlinear systems, their behavior, characteristic features and stability, Feedback Linearization, Feedback linearization and The canonical form, input-state linearization, input-output linearization, concept of zero dynamics, Mathematical Tools, Lie Algebra, input-state linearization of SISO Systems, Input-Output Linearization of SISO Systems and Multi-input Systems**;** Sliding Mode Control, sliding surface, graphical interpretation, Filippov's construction of the equivalent dynamics, perfect performance trade off, direct implementations of switching control laws, continuous approximations of switching control laws, modeling/performance trade-offs, SMC for multi-input systems**;** Back stepping Control, Integrator back stepping, strict feedback systems, recursive applications of back stepping, back stepping based control of multi input systems**;** Adaptive Control, basic concepts in adaptive control, Model Reference Adaptive Control (MRAC), Self-Tuning Control (STC), adaptive control of first-order systems, adaptive control of linear systems with full state feedback, adaptive control of linear systems with output feedback, adaptive control of nonlinear systems, robustness of adaptive control systems, online parameter estimation.

Course Outcomes

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

CO1: Develop description of different classes of nonlinear systems and associated control challenges.

CO2: Design feedback linearization control schemes for SISO and MIMO nonlinear systems.

CO3: Develop the robust design strategies to handle the systems with parametric uncertainities and disturbance.

CO4: Apply the adaptive control learning to develop online parameter estimation based control to address systems with constant or slowly varying uncertain parameters.

Books and References

1. Applied Nonlinear Control by J.J.E. Slotine & W. Li, Prentice Hall, Englewood Cliffs New Jersey.
2. Nonlinear Systems by Hassan K. Khalil, Prentice Hall, Englewood Cliffs New Jersey.
3. Nonlinear Dynamic Control Systems by H. Nimeijer & A.J. Van der Schaft, Springer Publisher.

Course Name: Microprocessor Based Instrumentation System
Course Code: EE-745
Course Type: Programme Elective-IV

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about the fundamentals for microprocessor-based instrumentation systems
- To introduce the basic concepts relevant to identify signal conditioning circuits for microprocessor-based instrumentation systems
- To enable the students to understand the interfacing of various peripheral devices and signal conditioning issues for a given problem/application.

Course Content

Microcontroller/Microprocessor an overview: Basic differences and similarities between Microprocessor and Microcontroller. Introduction to various Microcontrollers, Difference between 8-bit / 16-bit, RISC / CISC, Concept of pipelining. Introduction to 8051 Microcontroller: Intel 8051 history, Pin diagram of 8051, 8051-architecture, Registers, Timers Counters, Flags, Special Function Registers, DPTR, PC, PSW, SP etc. Additional features in 8052.Addressing Modes, Data types and Directives, Jump, Loop and Call instructions Arithmetic instructions, and their simple programming applications. Microcontroller/microprocessor-based Instrumentation: Interfacing with LEDs, Seven Segment, LCD, Sensors, ADC, DAC, Stepper Motor, Relays etc., Case studies based on Microcontroller/ microprocessor.

Course Outcomes

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

CO1: Understanding of the basic instrumentation systems and microprocessor-based systems and signal conditioning circuits.

CO2: An idea about the evolution of microprocessors/microcontrollers.

CO3: Understanding of various types of signal conditioning circuits.

CO4: Understanding of the interfacing of ADC, DAC, S/H, and sensors/transducers to microprocessor/ microcontroller using peripheral devices.

Books and References

1. Microprocessor and Interfacing (Programming and Hardware) by Douglas V. Hall, TMH, India.
2. Fundamentals of microprocessors and microcomputers by B. Ram Dhanpat Rai Publication.
3. Microprocessor, Microcomputer and their applications by A.K. Mukhopadhyay, Narosa Pub.
4. Microprocessors with applications in process control by S.I. Ahsan (TMH) India.
5. Microprocessors comprehensive studies by Naresh Grover, Dhanpat Rai & Co.
6. Transducers in instrumentation by D. V. S. Murthy, Prentice Hall.

Course Name: Linear System Theory
Course Code: EE-746
Course Type: Programme Elective-IV

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about matrix algebra and linear algebra.
- To introduce the fundamental concepts relevant linear systems and their analysis.
- To enable the students to understand techniques for the analyais and stability of linear systems.

Course Content

Introduction: causality, linear systems, linear time invariant systems, Matrix algebra, Linear algebra: subspaces and linear transformations. Basic concepts from analysis - normed spaces, continuity, convergence Linear differential equations: linearization, state-transition matrix, variation of constants formula, periodic systems. Matrix similarity, matrix exponentials, characteristic polynomial, Cayley Hamilton Theorem, Jordan normal form. Inner product spaces, orthogonal projections, normal matrices, symmetric and orthogonal matrices. Continuous and discrete-time linear systems; sampled systems; the concept of a realization. Controllability: reachable states, control reduction, controllable decompositions. Observability: unobservable states, observability reduction; minimal systems. Transfer matrix realizations; via partial fractions; via control canonical form; minimal realizations; isomorphic systems. Uniform and exponential stability; stability of continuous and discrete time-invariant systems, Routh-Hurwitz test, Lyapunov stability, perturbed systems. Feedback control: state-feedback, spectrum assignment, observers, observer-based control systems.

Course Outcomes

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

CO1: To apply the concepts of linear algebra for the analysis of linear systems

CO2: Solve design problems related to linear systems

CO3: Apply principles and concepts in stability analysis of linear systems.

Books and References

1. Linear System Theory by W. J. Rugh, Prentice Hall.
2. Linear Systems by T. Kailath, PHI, Englewood cliff, NJ.
3. Linear system theory and design by Chi-Tsong Chen, Oxford University Press.
4. Modern Control Engineering by K. Ogata, Prentice Hall of India.
5. Control System Engineering by Nagrath and Gopal, New Age International.
6. Automatic control Systems by B.C. Kuo Prentice Hall of India.

Course Name: Signal Processing Lab
Course Code: EE-644

Contact Hours/Week**: 4P**	Course Credits: **02**

Course Objectives

- To develop programming skills for conducting research in the field of signal processing.
- To develop an ability to work with some practical signals like speech, ECG etc.
- To implement the concepts of Adaptive filters studied in theory course.
- To illustrate effects of basic image enhancement and edge detection techniques on Images.

List of Experiments

1. To generate elementary discrete time sequence of following signals
    a. Impulse.
    b. Step.
    c. Ramp.
    d. Parabolic.
    e. Sinusoidal signal.
2. To design of FIR Digital filter using
    a. Window method
    b. Frequency sampling method
3. To design of IIR Digital filter using analog filter design
    a. Chebyshev filter
    b. Butterworth filter.
4. To detect the characteristics points of an ECG signal
5. To implement LMS algorithm and its variants for system identification.
6. To estimate pitch of voice signal.
7. To implement RLS algorithm and its variants for system identification
8. To implement a Speech coding algorithm.
9. To implement image enhancement techniques.
10. To implement edge detection approaches.

Note: *The concerned Course Coordinator will prepare the actual list of experiments/problems at the start of semester based on above generic list.*

Course Outcomes

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

CO1: Design FIR & IIR filters for a given specification.
CO2: Develop basic application using speech signals.
CO3: Collect an ECG signal from a subject using ECG setup/machine and process it using basic filters.
CO4: Improve the quality of images and extract features from them.