Department of Electrical and Electronics Engineering

Birla Institute of Technology, Mesra, Ranchi - 835215 (India)

Course Information Sheet
for
M.Tech in Electrical Engineering (Control System)

Institute Vision

To become a Globally Recognized Academic Institution in consonance with the social, economic and ecological environment, striving continuously for excellence in education, research and technological service to the National needs.

Institute Mission

- To educate students at Undergraduate, Post Graduate, Doctoral, and Post-Doctoral levels to perform challenging engineering and managerial jobs in industry.
- To provide excellent research and development facilities to take up Ph.D. programs and research projects.
- To develop effective teaching and learning skills and state of art research potential of the faculty.
- To build national capabilities in technology, education and research in emerging areas.
- To provide excellent technological services to satisfy the requirements of the industry and overall academic needs of society.

Department Vision

To become an internationally recognized center of excellence in academics, research and technological services in the area of ***Electrical and Electronics Engineering*** and related inter-disciplinary fields.

Department Mission

- Imparting strong fundamental concepts to students and motivate them to find innovative solutions to engineering problems independently.
- Developing engineers with managerial attributes capable of applying appropriate technology with responsibility.

- Creation of congenial atmosphere and ample research facilities for undertaking quality research to achieve national and international recognition by faculty and students.
- To strive for internationally recognized publication of research papers, books and to obtain patent and copyrights.
- To provide excellent technological services to industry for the benefit of society.

Program Educational Objectives (PEOs)

PEO 1: To acquire in-depth knowledge of complex Electrical Engineering problems especially in Control Systems to impart ability to discriminate, evaluate, analyze critically and synthesize knowledge pertaining to state of art and innovative research.

PEO 2: To solve complex control system problems with commensurate research methodologies as well as modern tools to evaluate a broad spectrum of feasible optimal solutions keeping in view socio- cultural and environmental factors.

PEO 3: To posses wisdom regarding group dynamics to efficaciously utilize opportunities for positive contribution to collaborative multidisciplinary engineering research and rational analysis to manage projects economically.

PEO 4: To communicate with engineering community and society at large adhering to relevant safety regulations as well as quality standards.

PEO 5: To inculcate the ability for life-long learning to acquire professional and intellectual integrity, ethics of scholarship and to reflect on individual action for corrective measures to prepare for leading edge position in industry, academia and research institutes.

PROGRAM OUTCOMES (POs)

Compulsory PO

PO1: An ability to independently carry out research /investigation and development work to solve practical problems.

PO2: An ability to write and present a substantial technical report/document.

PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

Optional PO (Program Specific)

PO4: Recognise the need for continuous learning and will prepare oneself to create, select and apply appropriate techniques and modern engineering and IT tools to solve complex control system problems.

PO5: Demonstrate knowledge of engineering and management principles and apply to manage projects efficiently and economically with intellectual integrity and ethics for sustainable development of society.

PO6: Possess knowledge and understanding to recognize opportunities and contribute to collaborative-multidisciplinary research, demonstrate a capacity for teamwork, decision-making based on open-mindedness and rational analysis in order to achieve common goals.

COURSE INFORMATION SHEET

Course code: EE501
Course title: Advanced Digital Signal Processing
Pre-requisite(s): Basics of signals and systems, transform methods, Filter theory.

Credits: 3	L	T	P
	3	0	0

Class schedule per week: 3 Lectures
Class: M.Tech
Semester / Level: I/05
Branch: Electrical Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1.	enumeratethe basic concepts of signals and systems and their interconnections in a simple and easy-to-understand manner by employingdifferent mathematical operations like folding, shifting, scaling, convolutions, Z-transform etc;
2.	determine transfer function, impulse response and comment on various properties like linearity, causality, stability of a system;
3.	predict time and frequency response of discrete-time systems using various techniques like Z-transform**,** Hilbert transform**,** DFT, FFT;
4.	designdigital IIR and FIR filters using filter approximation theory, frequency transformation techniques, window techniques and finally construct different realisation structures;
5.	apply DSP processor in processing of 1D and 2D signals.

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

CO1	state sampling theorem and reproduce a discrete-time signal from an analog signal; acquire knowledge of multi rate digital signal processing, STFT and wavelets;
CO2	classify systems based on linearity, causality, shift-variance, stability criteria and represent transfer function of the selected system;
CO3	evaluate system response of a system using Z-transform, convolution methods, frequency transformation technique, DFT, DIF-FFT or DIT-FFT algorithm, window techniques;
CO4	designFIR and IIR filters used as electronic filter, digital filter, mechanical filter, distributed element filter, waveguide filter, crystal filter, optical filter, acoustic filter, etc.;
CO5	construct (structure) and recommend environment-friendly filter for real- time applications.

SYLLABUS

EE501 Advanced Digital Signal Processing

Module I

Introduction: Overview of discrete time signal and systems, Types of discrete time systems, Analysis of discrete-time linear time invariant systems, Multirate signal processing: Decimation by factor D, I sampling rate conversion by a rational factor I/D. Z-transform, Properties of Z-transform, Inverse of Z-transform, Chrip Z-ransform, Zury's test for stability, Digital filter structures: Direct form I & II, Cascade, Parallel and Ladder realizations.

(8L)

Module II

Frequency domain analysis: Discrete Fourier transform (DFT), Inverse DFT, Inter relationship with z-transform and Hilbert-transforms, Discrete Hilbert transform, FFT algorithms- Decimation in time and decimation in frequency. Spectral analysis using DFT, Short term DFT.

(8L)

Module III

Filter function approximation, transforms and IIR filter design: Review of approximation of ideal analog filter response. Butterworth, Chebyshev type I & II, IIR filter designs based on impulse invariant and Bilinear transformation.

(8L)

Module IV

Design of FIR Filters: Characteristic of FIR filters with linear phase, Symmetric and antisymmetric FIR filters, design of linear phase FIR filters using windows and frequency sampling methods, comparison of FIR and IIR filters.

(8L)

Module V

DSP Processor and applications: Introduction to DSP processor, Types of architectures, DSP support tools, code composer studio, compiler, assembler and linker, Introduction TMS320 C6x architecture, functional units, fetch and execute packets, pipe lining, registers, Linear and circular addressing modes. DSP applications in the area of biomedical signal, speech, and image.

(8L)

Books Recommended:

Text Book

1. John G. Proakis, Dimitris G. Mamalakis, Digital Signal Processing, Principles, Algorithms and Applications.

2. Alan V. Oppenheim Ronald W. Schafer, Digital Signal Processing, PHI, India.

Reference Book

1. Antonious, Digital Filter Design, Mc-Graw-Hill International Editions.
2. S. Salivahanan C Gnanapriya, Digital Signal Processing, Tata McGraw Hill Education Private Limited.
3. A. NagoorKani, Digital Signal Processing, McGraw Hill Education Private Limited.

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements):

1. Visualize different signal processing techniques in real time.
2. Application of real time implementation of digital filter.

POs met through Gaps in the Syllabus:PO5 & PO6

Topics beyond syllabus/Advanced topics/Design:

Adaptive signal processing, Image processing.

POs met through Topics beyond syllabus/Advanced topics/Design: PO5 & PO6

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	-	-	-
CO2	3	2	1	2	-	1
CO3	3	1	2	3	-	1
CO4	2	2	2	3	2	2
CO5	2	2	3	1	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD6
CO2	CD1, CD6,CD7
CO3	CD1, CD2, CD3,CD6,CD7
CO4	CD1, CD3,CD6,CD7
CO5	CD1,CD2,CD3,CD4,CD5,CD7

COURSE INFORMATION SHEET

Course code: EE503
Course title: Modern Control Theory
Pre-requisite(s): B.E./B.Tech. in ECE/EEE with basic courses on Control Theory
Co- requisite(s): Linear Algebra

Credits: 3	L	T	P
	3	0	0

Class schedule per week: 03
Class: M.Tech.
Semester / Level: I/05
Branch: Electrical Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1.	state basic concepts of state variables, state diagrams, controllability, observability;
2.	extend comprehensive knowledge of mathematical modelling of physical system;
3.	illustrate basics of transformations and decompositions for controllability and observability tests;
4.	enhance skills with application of different control strategy for designing a control problem;
5.	design controller for any type of linear plants.

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

CO1	demonstrate an understanding of the building blocks of basic and modern control systems by creating mathematical models of physical systems in input-output or transfer function form;
CO2	organize state representations to satisfy design requirements using transformations and decompositions;
CO3	examine state space equations for time domain analysis;
CO4	assess a system for its stability, controllability, and observability properties leading to design of controller and observer in a feedback control system;
CO5	aspire for pursuing a carrier in control, recognize the need to learn, to engage and to adapt in a world of constantly changing technology and play role of team leader or supporter of team.

SYLLABUS

EE503 Modern Control Theory

Module I

Background and Preview, Modelling, Highlights of Classical Control Theory; Block diagram, Transfer functions, State Variables and State Space description of dynamic systems, State diagrams, Differential equations to state diagrams, State diagrams to Transfer function, State diagrams to state and output equations, State equations from system's linear graph.

(8L)

Module II

Fundamentals of Matrix Algebra, Vectors and Linear Spaces, Simultaneous Linear Equations, Eigenvalues and Eigenvectors, Functions of Square Matrices, Similarity Transformations, CCF, OCF, DCF and JCF forms, Decomposition of Transfer Functions, The Caley-Hamilton Theorem and it's applications.

(8L)

Module III

Analysis of Continuous and Discrete-Time Linear State Equations, Local linearization of non-linear models, State Transition Matrix, Significance, Properties and Evaluation of STM, Stability analysis using direct method of Lyapunov.

(8L)

Module IV

Controllability and Observability concept for linear Systems, Relationship among Controllability, Observability and Transfer Functions, Invariant theorems on Controllability and Observability.

(8L)

Module V

Design of Linear Feedback Control Systems, pole placement design through state feedback, Design of servo systems, State observers, Design of Regulator Systems with observers, Design of control systems with Observers, Quadratic Optimal Regulator Systems.

(8L)

Books Recommended:

Text Book

1. Modern Control Theory by Brogan, Pearson, 3rd edition. (**T1**)
2. Systems and Control by Zak, 1st edition, Oxford University Press. **(T2)**

3. Modern Control System Theory by M. Gopal, New Age International(P) Ltd., 2nd edition. (**T3**)
4. Automatic Control Systems by F. Golnaraghi and B.C.Kuo, Wiley Student Edition, 9th edition. (**T4**)
5. Modern Control Engineering by K. Ogata, Pearson, 5th edition (**T5)**

Reference Book

1. Digital Control & State Variable Methods – M. Gopal, Tata McGraw Hill Education. (**R1**)
2. Linear Systems by Thomas Kailath, Prentice-Hall Inc.,1980. (**R2**)

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations.

Gaps in the syllabus (to meet Industry/Profession requirements):

1. Design of real-time industrial projects.

POs met through Gaps in the Syllabus: PO5 & PO6

Topics beyond syllabus/Advanced topics/Design:

1. Design optimization for industrial projects, Fractional order controller.

POs met through Topics beyond syllabus/Advanced topics/Design:PO5 & PO6

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	-	1	3	-	-
CO2	3	-	1	3	-	1
CO3	3	1	2	3	-	1
CO4	3	2	2	3	2	2
CO5	3	3	3	3	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD6
CO2	CD1, CD6,CD7
CO3	CD1, CD2, CD3,CD6,CD7
CO4	CD1, CD3,CD6,CD7
CO5	CD1,CD2,CD3,CD4,CD5,CD7

COURSE INFORMATION SHEET

Course code: EE505
Course title: System Identification and Adaptive Control
Pre-requisite(s): Fundamentals of signal and system, Digital signal processing,
Credits: 3

L	T	P
3	0	0

Class schedule per week: 03
Class: M. Tech.
Semester / Level: I/05
Branch: Electrical Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1.	illustrate the process of System Identification and interpret data based identification techniques;
2.	understand the concepts of Time invariant systems identification and apply it to specific real time numerical problems;
3.	illustrate and summarize the techniques of Adaptive Control;
4.	derive necessary and sufficient conditions for Input/Output, Lyapunov (Direct and Indirect) stability;
5.	develop adaptive laws for On-line Parameter Estimation and derive schemes and procedures for Direct Model Reference Adaptive Control.

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

CO1	enumerate the process of System identification and apply the data based identification techniques to identify transfer functions of unknown plant models;
CO2	apply the static and dynamic system identification techniques to identify the estimated states for the unknown or perturbed time invariant plant models;
CO3	state and interpret the concepts of adaptive control and determine Input/Output and Lyapunov stability of a LTI feedback system;
CO4	apply various techniques or laws of adaptation for online parameter estimation and reproduce the results and write effective reports suitable for quality journal and conference publications ;
CO5	design adaptive observers and model reference adaptive control for SISO and MIMO plants and simultaneously recognize the need to learn, to engage and to adapt in a world of constantly changing technology and play role of team leader or supporter of team.

SYLLABUS

System Identification and Adaptive Control

Module I

Introduction to System Identification: Data based identification (System Response Methods, Frequency Response Methods, Correlation Methods.

(8L)

Module II

Time Invariant Systems Identification: Static Systems Identification, Dynamic Systems Identification.

(8L)

Module III

Introduction to Adaptive Control: Models for Dynamic Systems, Stability.

(8L)

Module IV

On-line Parameter Estimation: Fundamentals of random signals, Spectral estimation, Optimum (Wiener and Kalman) linear estimation, Extended Kalman filter, Particle filter, Parameter Identifiers and Adaptive Observers.

(8L)

Module V

Model Reference Adaptive Control (MRAC): Simple Direct MRAC Schemes, MRC for SISO Plants, Direct MRAC with Unnormalized Adaptive Laws, Direct MRAC with Normalized Adaptive Laws.

(8L)

Books recommended:

Text Books:

1. Systems Identification: An Introduction – Karel J. Keesman, Springer, 2011.
2. Robust Adaptive Control - Petros A. Ioannou and Jing Sun, 1996.
3. Optimization, Estimation and Control - A.E. Bryson & Y.C. Ho
4. Applied Optimal Estimation - A. Gelb, NIT Press, Cambridge
5. Optimal Estimation, Identification and Control - RCK Lee, NIT Press, Combridge, Massachusetts, 1964.
6. Stochastic Optimal Linear Estimation and Control - J.S. Meditch, McGraw Hill, N.Y., 1969.

Course Evaluation:
Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements):
Design of real-time industrial projects.
POs met through Gaps in the Syllabus:**PO5 & PO6**

Topics beyond syllabus/Advanced topics/Design:
Advanced topic in adaptive signal processing, Artificial Intelligence Techniques.

POs met through Topics beyond syllabus/Advanced topics/Design: **PO5 & PO6**

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	-	1	3	-	-
CO2	2	-	1	2	-	-
CO3	2	1	2	2	-	2
CO4	2	2	2	3	2	2
CO5	2	3	3	1	1	1

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD6
CO2	CD1, CD6,CD7
CO3	CD1, CD2, CD3,CD6,CD7
CO4	CD1, CD3,CD6,CD7
CO5	CD1,CD2,CD3,CD4,CD5,CD7

COURSE INFORMATION SHEET

Course code: EE511
Course title: Optimization in Engineering Design
Pre-requisite(s): Fundamental of Engineering Mathematics
Co- requisite(s):

Credits: 3	L	T	P
	3	0	0

Class schedule per week: 03
Class: M.Tech.
Semester / Level: I/05
Branch: Electrical Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	conceptualize the optimizations in engineering design and model the problem mathematically;
2	understand various optimization methods and algorithms for solving optimization problems;
3	develop substantial interest in research, for applying optimization techniques in problems of engineering and technology;
4	analyze and apply mathematical results and numerical techniques for optimization of engineering problems, while being able to demonstrate solutions through computer programs;
5	formulate the optimization criteria for real time applications.

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

CO1	have a basic understanding of traditional and non-traditional optimization algorithms;
CO2	formulate engineering design problems as mathematical optimization problems;
CO3	use mathematical software for the solution of engineering problems;
CO4	differentiate the various optimization concepts and equivalently apply them to engineering problems;
CO5	evaluate pros and cons for different optimization techniques.

SYLLABUS

EE511 Optimization in Engineering Design

Module I

One-Dimensional Search and Multivariable Optimization Algorithm: Optimality Criteria, Bracketing methods: Exhaustive search methods, Region – Elimination methods; Interval halving method, Fibonacci search method, Golden section search method, Point-estimation method; Successive quadratic estimation method. Optimality criteria, Unidirectional search, Direct search methods: Simplex search method, Hooke-Jeeves pattern search method

(8L)

Module II

Gradient-Based Methods: Newton-Raphson method, Bisection method, Secant method, Cauchy's (Steepest descent) method and Newton's method.

(8L)

Module III

Linear Programming: Graphical method, Simplex Method, revised simplex method, Duality in Linear Programming (LP), Sensitivity analysis, other algorithms for solving LP problems, Transformation, assignment and other applications.

(8L)

Module IV

Constrained Optimization Algorithm: Characteristics of a constrained problem. Direct methods: The complex method, Cutting plane method, Indirect method: Transformation Technique, Basic approach in the penalty function method, Interior penalty function method, convex method.

(8L)

Module V

Advanced Optimization Techniques: Genetic Algorithm, Working principles, GAs for constrained optimization, Other GA operators, advanced GAs, Differences between GAs and traditional methods. Simulated annealing method, working principles. Particle swarm optimization method, working principles.

(8L)

Books Recommended:

Reference Book:

1.Optimization for Engineering Design - Kalyanmoy Deb.

2. Optimization Theory and Applications - S.S. Rao.

3. Analytical Decision Making in Engineering Design – Siddal.
4. Linear Programming – G. Had

Course Evaluation:
Individual assignment, Theory (Quiz and End semester) examinations

<u>Gaps in the syllabus (to meet Industry/Profession requirements)</u>:
Validation of optimization based designfor industrial projects.
POs met through Gaps in the Syllabus:**PO6**

<u>Topics beyond syllabus/Advanced topics/Design:</u>
Genetic Algorithm based machine design.
<u>POs met through Topics beyond syllabus/Advanced topics/Design</u>: PO6

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

<u>MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES</u>

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	-	1	3	-	-
CO2	3	-	1	3	-	1
CO3	3	1	2	3	-	1
CO4	3	2	2	3	2	2
CO5	3	3	3	3	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

<u>MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD</u>

Course Outcomes	Course Delivery Method
CO1	CD1,CD6
CO2	CD1, CD6,CD7
CO3	CD1, CD2, CD3,CD6,CD7
CO4	CD1, CD3,CD6,CD7
CO5	CD1,CD2,CD3,CD4,CD5,CD7

COURSE INFORMATION SHEET

Course code: EE513
Course title: Robotics and Automation
Pre-requisite(s): EngineeringMathematics, Signal and systems, Control Theory, Basic programming knowledge.
Co- requisite(s):

Credits: 3	L	T	P
	3	0	0

Class schedule per week: 03
Class: M.Tech.
Semester / Level: I/05
Branch: Electrical Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	to explain the characteristics of robots, discuss different types of sensors and basic programming languages used for robotics;
2	to relate direct and inverse kinematics problem of robots and apply methods to solve them and to use techniques for planning robot motions;
3	to explain different methods for control of robotic manipulators;
4	to design suitable controllers and check stability for robotic manipulators;
5	to recommend the use of robotic vision in different applications of robots.

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

CO1	enumerate and explain characteristics of robots, sensors used in robots and basic programming languages;
CO2	correlate direct and inverse kinematics to real life problems and apply the algorithm to solve them;
CO3	explain and analyse different control techniques and evaluate planning algorithms for robot motions;
CO4	assess the use of computer vision/machine vision to different robot applications and appraise the use of artificial intelligence in different field of robotics;
CO5	solve real life applications using direct and inverse kinematics and simulate different controllers;

SYLLABUS

EE513 Robotics and Automation

Module I

Basic components of robotic systems,Robot classification, Robot specifications, Applications, Direct Kinematics: Coordinateframes; Rotations; Homogeneous coordinates; D-H representation; The Arm Equation.

(8L)

Module II

Inverse Kinematics: Inverse kinematics problem, General properties of solutions, Tool configuration, Robotic work cell, Workspace analysis. Trajectory planning. Workspace envelope. Workspace fixtures. Pick and place operation. Continuous-path motion. Interpolated motion. Straight line motion.

(8L)

Module III

Sensing and Control of Robot Manipulators: Different sensors in robotics: Range; Proximity; Touch; Torque; Force and others. Computed torque control; Near Minimum time control; Variable structure control; Non-Linear decoupled feedback control; Resolved motion and Adaptive control.

(8L)

Module IV

Robotic Vision: Image acquisition and Geometry. Pre-processing; Segmentation and Description of 3-D structures; Recognition and Interpretation. .

(8L)

Module V

Robot Arm Dynamics: Lagrange-Euler formulation; Newton Euler formulation; Generalized D'Alembert's equation.
Robot Programming Languages, Robot Intelligence and Task Planning: Characteristics of Robot level languages. Task level languages- with examples C, prolog. Assembly etc. Problem reduction; Use of predicate logic; Robot learning; Expert systems.

(8L)

Books recommended:

Text Book

1. Fundamental of Robotics: Analysis and Control- Robert J. Schilling. **[T1]**
2. Robotics: Control, Sensing,Vision and Intelligence- K.S. Fu, R.C. Gonzalez and Lee. **[T2]**

Reference Book

1. Robotics and Control – R. K. Mittal and I. J. Nagrath. (**R1**)

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements):

Simulation to meet real time implementation of techniques for control of robots

POs met through Gaps in the Syllabus: **1,2,3,4,5,6**

Topics beyond syllabus/Advanced topics/Design:

Simulation given to students as assignments

POs met through Topics beyond syllabus/Advanced topics/Design: **1,2,3,4,5,6**

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Self- learning such as use of NPTEL materials and internets
CD5	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	3	3	-
CO2	3	-	3	3	-	3
CO3	3	3	3	3	3	3
CO4	3	3	3	3	3	-
CO5	3	-	3	3	3	-

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcome	Course Delivery Method
CO1	CD1,CD2,CD4
CO2	CD1,CD2,CD4
CO3	CD1,CD2,CD3,CD4,CD5
CO4	CD1,CD2,CD3,CD4,CD5
CO5	CD1,CD2,CD3,CD4,CD5

COURSE INFORMATION SHEET

Course code: EE515
Course title: Control System Design
Pre-requisite(s): Fundamentals of Mathematics andPhysics, Introduction to System Theory, Control Theory
Co- requisite(s): Linear Algebra

Credits: 3	L	T	P
	3	0	0

Class schedule per week: 3
Class: M.Tech.
Semester / Level: I/05
Branch: Electrical Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	to state the performance characterisitics of control systems with specific design requirements and design objectives;
2	to understand the concepts of PD, PI, PID, lead, lag and lag lead controller design in time domain and frequency domain and apply it to specific real time numerical problems;
3	to apply the state feedback controller and observer design techniques to modern control problems and analyse the effects on transient and frequency domain response;
4	to realize and then design digital and analog compensators;
5	design controller for any type of linear plants.

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

CO1	identify the design objectives and requirements of control systems;
CO2	interpret the concepts of PD, PI, PID, lead, lag, lag lead, and discrete data controller design and apply it to solve some design problems;
CO3	apply the state feedback controller design and techniques and outline its effects on system's performance which includes transient response and robustness;
CO4	to develop methodologies to design real time digital and analog compensatorsand reproduce the results and write effective reports suitable for quality journal and conference publications;
CO5	aspire for pursuing a carrier in control, recognize the need to learn, to engage and to adapt in a world of constantly changing technology and play role of team leader or supporter of team.

SYLLABUS

EE515 Control System Design

Module I

Introduction: Performance characteristics of feedback control system & design specification of control loop. Different types of control system applications and their functional requirement. Derivation of load-locus (toque/ speed characteristics of load). Selection of motors, sensors, drives. Choice of design domain & general guidelines for choice of domain. Controller configuration and choice of controller configuration for specific design requirement. Fundamental principles of control system design. Experimental evaluation of system dynamics in time domain and frequency domain

(8L)

Module II

Design of Controller: Design with PD Controller, Time domain interpretation of PD controller, frequency domain interpretation of PD controller, summary of the effects of PD controller. Design with PI controller: Time domain interpretation of PI controller frequency domain interpretation of PI controller, summary of the effects of PI controller, design with PID controller, Ziegler Nichols tuning & other methods.

(8L)

Module III

Design of Compensator: time domain interpretation of lag/lead/lag-lead compensator, frequency domain interpretation of lag/lead/lag-lead compensator, summary of the effects of lag/lead/lag-lead compensator. Forward & feed-forward controller, minor loop feedback control, concept of robust design for control system, pole-zero cancellation design. .

(8L)

Module IV

State Space Model: Sate feedback control, pole placement design through state feedback, state feedback with integral control, design full order and reduced order state observer.

(8L)

Module V

Design of Discrete Data Control System: Digital implementation of analog controller (PID) and lag-lead controllers, Design of discrete data control systems in frequency domain and Z plane.

(8L)

Books recommended:

Text Books:

1. B.C. Kuo, "Automatic Control System", 7th Edition PHI. (T1)
2. M. Gopal, "Control Systems Principles & Design", 2nd Edition, TMH. (T2)
3. J.G. Truxal, "Automatic Feedback Control System", McGraw Hill, New York. (T3)
4. K. Ogata, "Discrete Time Control Systems", 2nd Edition, Pearson Education. (T4)

Reference Books:

1. Norman Nise,"Control System Engineering", 4th Edition. (R1)
2. M. Gopal, "Digital Control & State Variable Method", TMH. (R2)
3. B.C. Kuo, "Digital Control System", 2nd Edition, Oxford. (R3)
4. Stephanie, "Design of Feedback Control Systems", 4th Edition, Oxford. (R4)

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements)

1. Real time analog design of controllers.
2. Interfacing the controllers with the real time physical plants to identify the effects on system's performance. **PO5 & PO6**

Topics beyond syllabus/Advanced topics/Design:

Advanced robust design methods for different control problems

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors
CD2	Tutorials/Assignments
CD3	Mini projects/Projects
CD4	Laboratory experiments/teaching aids
CD5	Self- learning such as use of NPTEL materials and internets
CD6	Simulation

<u>MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES</u>

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	1	2	-	-
CO2	3	2	1	3	-	1
CO3	3	1	2	3	-	1
CO4	3	3	2	3	2	2
CO5	3	3	3	3	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1
CO2	CD1,CD2,CD6
CO3	CD1,CD2,CD6
CO4	CD1,CD2,CD6
CO5	CD1, CD5

COURSE INFORMATION SHEET

Course code: EE551
Course title: Image Processing and Computer Vision
Pre-requisite(s): Basics of signals and systems, transform methods, Filter theory.

Credits: 3	L	T	P
	3	0	0

Class schedule per week: 03
Class: M.Tech
Semester / Level: I/05
Branch: Electrical Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	understand the basic steps of the digital image processing and basic of computer vision;
2	understand the concepts of Image Transform, Image Restoration, Segmentation and Compression;
3	illustrate and summarize the technique of shape representation, feature extraction, boundary descriptors, and regional descriptors;
4	design adaptive algorithm suitable for image de-noising, object tracking, vision based control etc.;
5	develop adaptive algorithm for other image processing and computer vision applications.

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

CO1	recognise the basic steps of the digital image processing such as Image Transform, Image Restoration, Segmentation and Compression;
CO2	understand the basic concept of computer vision and investigate different associated methodology;
CO3	recapitulate the technique of shape representation, feature extraction, shape representation, feature extraction, edge detection, boundary descriptors, and regional descriptors;
CO4	apply various techniques of image processing for object recognition, motion estimation, object tracking;
CO5	design apply various adaptive algorithm for vision based control, vision for human computer interaction etc.

SYLLABUS

EE551 Image Processing and Computer Vision

Module I

Digital Image Fundamentals: Fundamental steps in Digital Image Processing, Components of an Image processing system, Digital Image Representation, Basic relationship between pixels, Color Modules, Image negatives, Histogram Equalization, Local Enhancement, Image Subtraction, Image Averaging, Smoothing Spatial Filters, Sharpening Spatial Filters.

(8L)

Module II

Image Transform: Fourier Transform, Discrete Fourier Transform, Fast Fourier Transform, Smoothing Frequency Domain filters, Sharpening Frequency Domain filters, Homomorphic filtering, Convolution and Correlation Theorems, Wavelet Transforms, The Fast Wavelet Transforms.

(8L)

Module III

Image Restoration, Segmentation and Compression: Noise Models, Mean filters, Median Filter, Minimum Mean Square Error (Wiener) Filtering, Geometric Mean Filter, Adaptive filters, Periodic Noise Reduction by Frequency Domain filtering, Inverse Filtering, Detection of Discontinuities, Point Detection, Line detection, Edge Detection, Fundamentals of image compression, Redundancy, Image Compression Models, Error-free and Lossy Compression techniques.

(8L)

Module IV

Computer vision Fundamentals: Shape Representation, Description and Feature Extraction: Deformable curves and surfaces, Snakes and active contours, Level set representations, Linear Filters, Texture, Edge detection, Boundary Descriptors, Regional Descriptors.

(8L)

Module V

Image Processing and Computer Vision Applications: Denoising of Image as pre-processing, Object recognition, Motion estimation, Object Tracking, Vision based control, vision for human computer interaction.

(8L)

Text Books:

1. R.C.Gonzalez and Richard E Woods, Digital Image Processing, 2e, Pearson Education.
2. D. A. Forsyth, J. Ponce, Computer Vision: A Modern Approach, PHI Learning 2009

Reference Book:
1. B.Chanda and D. Dutta Majumdar, Digital Image Processing and Analysis, PHI.

Course Evaluation:
Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements):
Design of real-time industrial projects.
POs met through Gaps in the Syllabus:**PO4 & PO5**

Topics beyond syllabus/Advanced topics/Design:
Object Tracking, Video compression.
POs met through Topics beyond syllabus/Advanced topics/Design: **PO5 & PO6**

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	3	1	1
CO2	2	1	1	3	1	1
CO3	2	2	3	3	2	1
CO4	3	1	2	3	2	2
CO5	3	3	3	3	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD6
CO2	CD1, CD6,CD7
CO3	CD1, CD2, CD3,CD6,CD7
CO4	CD1, CD3,CD6,CD7
CO5	CD1,CD2,CD3,CD4,CD5,CD7

COURSE INFORMATION SHEET

Course Code: EE 597
Course title: Reliability Engineering (Open Elective)
Pre-requisite(s): Engineering Mathematics, Probability Theory
Co- requisite(s):

Credits: 3	L	T	P
	3	0	0

Class schedule per week: 3
Class: M.Tech.
Semester / Level: I/05
Branch:
Name of Teacher:

Course Objectives
This course enables the students to:

1.	define probability theory and relate the concept of reliability of systems;
2.	understand general reliability mathematics applicable to all systems;
3.	understand Markov chains, and application of Markov models in reliability analysis of systems;
4.	evaluate reliability of systems using Markov models and available reliability parameters of systems;
5.	use frequency and duration technique for various reliability analysis problems.

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

1.	understand the general reliability concept and mathematics;
2.	identify events or causes responsible for unreliability of systems through failures;
3.	evaluate the associated system risk and thus finding solutions for minimizing the risks to an acceptable level;
4.	apply engineering knowledge and design techniques to prevent or to reduce the likelihood or frequency of failures for different systems;
5.	apply methods for estimating the reliability of new designs, and for analyzing reliability data.

SYLLABUS

EE597 Reliability Engineering

Module I

Introduction: Types of systems, Qualitative and quantitative assessment, Reliability definitions and concepts, Reliability indices and criteria, Reliability evaluation techniques, Reliability improvements, Reliability economics, Reliability monitoring and growth, Basic probability theory**,** Probability concepts, Permutations and combinations, Application in probability evaluation, Practical engineering concepts, Venn diagrams, Rules for combining probabilities, Probability distributions.

(8L)

Module I

Reliability Mathematics: The general reliability function, the exponential distribution, Mean time to failure and repair, series and parallel systems, Markov processes, System reliability using network and state space method.

(8L)

Module III

Network Modeling and Evaluation of Simple and Complex Systems: Service quality criterion, Conditional probability approach, Two-plant single load and two load systems. The probability array for two interconnected systems, Loss of load approach, Interconnection benefits.

(8L)

Module IV

Discrete Markov Chains and Continuous Markov Processes: Introduction toDiscrete Markov chain, Stochastic transitional probability matrix by Discrete Markov chain, Time dependent probability evaluation by Discrete Markov chain**,** Limiting state probability evaluation**,** Absorbing states, Application of discrete Markov techniques, Introduction to Continuous Markov process**,** General modeling concepts, State space diagrams, Stochastic transitional probability matrix by Continuous Markov process , Evaluating limiting state probabilities by Continuous Markov process, Reliability evaluation in repairable systems, Application of techniques to complex systems.

(8L)

Module V

Frequency and Duration Techniques: Frequency and duration concepts, Application to multi-state problems: Two component repairable system, State probabilities, Frequency of encountering individual states**,** Mean duration of individual states, Cycle time between individual states , Frequency of encountering cumulated states**,** Recursive evaluation of cumulative frequency, Mean duration of cumulated states, Frequency balance approach, Two stage repair and installation process :One component system-no spare available, one spare available, two spares available, one spare available, Limiting number of spares, Application of the techniques. (8L)

Text Books:

1. Roy Billinton, Ronald N. Allan, "Reliability Evaluation of Engineering Systems Concepts and Techniques", 2nd Edition, Springer Science + Business Media New York 1992.
2. Hoang Pham, "Handbook of Reliability Engineering", Springer 2003.
3. Alessandro Birolini, "Reliability Engineering: Theory and Practice", Springer 1999.

Reference Books:

1. Donald W. Benbow, "The Certified Reliability Engineer Handbook", 2009.

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design:

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3	-	1
CO2	3	3	2	2	1	1
CO3	3	3	2	2	1	1
CO4	3	3	2	2	1	1
CO5	3	3	2	2	1	1

< 34% = 1, 34-66% = 2, > 66% = 3

Mapping Between Course Outcomes and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD6
CO2	CD1, CD6, CD7
CO3	CD1, CD2, CD3, CD6, CD7
CO4	CD1, CD3, CD6, CD7
CO5	CD1, CD2, CD3, CD4, CD5, CD7

COURSE INFORMATION SHEET

Course code: EE502
Course title: Advanced Digital Signal Processing Laboratory
Pre-requisite(s): Basics of signals and systems, transform methods, Filter theory.
Credits: 2

L	T	P
0	0	4

Class schedule per week: 4
Class: M.Tech.
Semester / Level: I/05
Branch: Electrical Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1.	enumerate the basic concepts of signals and systems and their interconnections in a simple and easy-to-understand manner through different mathematical operations like folding, shifting, scaling, convolutions, etc. using MATLAB; also gain Knowledge of TMS kit, digital image filter;
2.	construct different realization structures;
3.	determine transfer function and predict frequency response of discrete-time systems by applying various techniques like Z-transform, DFT and FFT using MATLAB;
4.	evaluate cost of filters in terms of memory space complexity, algorithm complexity and economic values;
5.	design and compose digital IIR and FIR filters using filter approximation theory, for optimal cost.

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

CO1	convert analog signal into digital signals and vice-versa, generation of different signals and basic knowledge of TMS kit;
CO2	compute frequency response of the systems using frequency transformation technique, DFT, DIF-FFT or DIT-FFT algorithm, window techniques and visualization using MATLAB;
CO3	design FIR and IIR filters;
CO4	evaluate performance of filter with time variant signals;
CO5	recommend environment-friendly filter for different real- time applications such as optical filter design, acoustic filter design etc.

LIST OF EXPERIMENTS
EE502 Advanced Digital Signal Processing Laboratory

1. **Name: Introduction to MATLAB.**
   Aim: An introduction to MATLAB.

2. **Name: Generation and representation of different types of signal.**
   Aim: To perform generation of different signals in MATLAB.

3. **Name: The Z-Transform and Inverse Z-Transform.**
   Aim: To write a program to find z-transform of given signal.

4. **Name: The Cross-correlation, Auto-correlation between two sequences. Also, Circular convolution between two periodic sequence.**
   Aim: To perform cross-correlation, auto-correlation and circular convolution of two sequence.

5. **Name:- Discrete Fourier transform and Inverse- Discrete Fourier transform**
   Aim: To write an MATLAB program to find discrete Fourier transform and Inverse-discrete Fourier transform.

6. **Name: DFT by DIT-FFT and DIF-FFT method.**
   Aim: To perform DFT by DIT-FFT and DIF-FFT methods in MATLAB.

7. **Name: The low pass, high-pass, band-pass and band-stop filter using Butterworth approximation.**
   Aim: To write a MATLAB program for low pass, high pass and band pass filter using Butterworth approximation.

8. **Name: Familiarization with TMS-320C6713 DSP starter Kit.**
   Aim: To perform a descriptive and practical study for hardware of TMS- 320C6713 DSP starter Kit.

9. **Name: Correlation of two discrete time signal**
   Aim: To write a MATLAB program to perform correlation of two discrete time signal.

10. **Name: Linear convolution of two sequence using circular matrix method.**
    Aim: To write a MATLAB program to perform Linear convolution of two sequence using circular matrix method.

11. **Name: The Radix-2 DIT FFT algorithm.**
    Aim: To perform Radix-2 DIT FFT algorithm of 8-point sequence in MATLAB.

12. **Name: Image Processing.**
    Aim: 1.To write a program to remove Salt & paper type noise from a given image
    2. To change the colour of specific part of given image

3. Write a program to remove Gaussian noise from given image

Books Recommended:

1. Digital signal processing and applications with C6713 and C6416 DSK by RulphChassaing, wiley publication.
2. Real-Time digital signal processing based on the TMS320C6000 by Nasser Kehtarnavaz, ELSEVIER publication
3. DSP applications using C and the TMS320c6x DSK by RulphChassaing, Wiley Publication.

Reference Books:

1. Antonious,Digital Filter Design,Mc-Graw-Hill International Editions.
2. WavelateTransform,S.Rao.
3. WavelateAnalysis:“The scalable structure of Information”Springer2008–Howard L.Resinkoff,RaymondO.Wells

Course Evaluation:

Group project evaluation, Progressive and End semester evaluations

Gaps in the syllabus (to meet Industry/Profession requirements) :

1. Visualize different signal processing techniques in real time.
2. Application of real time implementation of digital filter.

POs met through Gaps in the Syllabus:PO5 & PO6

Topics beyond syllabus/Advanced topics/Design:

Adaptive signal processing, Image processing.

POs met through Topics beyond syllabus/Advanced topics/Design: PO5 & PO6

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	-	-	-
CO2	3	2	1	2	-	1
CO3	3	1	2	3	-	1
CO4	2	2	2	3	2	2
CO5	2	2	3	1	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD6
CO2	CD1, CD6,CD7
CO3	CD1, CD2, CD3,CD6,CD7
CO4	CD1, CD3,CD6,CD7
CO5	CD1,CD2,CD3,CD4,CD5,CD7

COURSE INFORMATION SHEET

Course code: EE504
Course title: Adaptive Control System Lab
Pre-requisite(s): Introductionto System theory, Control theory, Control system design
Co- requisite(s):

Credits: 2	L	T	P
	0	0	4

Class schedule per week: 04
Class: M.Tech.
Semester / Level: I/05
Branch: Electrical Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1.	to describe the basic components and various specifications of system;
2.	to explain and interpret the performance of different controllers;
3.	to analyse various techniques in time domain and frequency domain to ensure stability of a system;
4.	to simulate and test them on systems like Inverted Pendulum, Twin Rotor MIMO system (TRMS) and Magnetic Levitation System;
5.	to determine the response of different types of systems using real time workshop in Matlab and appraise their use in real life.

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

CO1	examine performance characteristics of basic components of a system and describe various specifications used for a system;
CO2	explain and interpret the performance characteristics of different sensors, DC motor, ON/OFF and PLC/PID Controllers;
CO3	analyse the effect of addition of poles and zeros in time domain and frequency domain;
CO4	appraise various techniques and analyse stability of a given system;
CO5	simulate and test the techniques on Inverted Pendulum, Twin Rotor MIMO system (TRMS) and Magnetic Levitation System.

LIST OF EXPERIMENTS
EE504 Adaptive Control System Lab

1. To study and implementation of ON-OFF temperature controller.
2. To obtain the step response of first and second order RLC series circuit and determine the value of R and L for a given value of C through time response specification.
3. To obtain Bode plot of the given circuit through experimentation and in term determine the transfer function through by calculations and simulate the same system in Matlab.
4. To obtain the Nyquist plot of the given transfer function and determine the gain margin, phase margin, gain crossover frequency, phase crossover frequency. Comment on the stability.
5. To obtain the characteristics of synchros.
6. To obtain the characteristics of Linear Variable Differential Transformer (LVDT).
7. Study the effect of addition of poles and zeros and correlate the time and frequency domain behavior using MATLAB sisotool for a given system.
8. To study the characteristics of different sensors and transducers.
9. To design a PID controller for a DC motor using Z-N method and verify it in MATLAB.
10. Pole placement design of Inverted pendulum
11. PLC / PID controller based Pressure control using Process trainer kit
12. Study the operation of Twin rotor MIMO system
13. Study the operation of Magnetic Levitation system

Books recommended:

Text Books:

1.M. Gopal, "Control Systems Principles & Design", 2nd Edition, TMH. (T2)
2.K. Ogata, "Discrete Time Control Systems", 2nd Edition, Pearson Education. (T4)

Reference Books:

1.Norman Nise, "Control System Engineering", 4th Edition. (R1)

2.M. Gopal, "Digital Control & State Variable Method", TMH. (R2)
3.B.C. Kuo, "Digital Control System", 2nd Edition, Oxford. (R3)

Course Evaluation:

Individual assignment, Journal, Rough Copy, Regularity and daily viva (Progressive Evaluation), Lab performance and Viva-Voce (End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements):
Real time implementation of techniques to meet industry requirements

POs met through Gaps in the Syllabus: **1,2,3,4**

Topics beyond syllabus/Advanced topics/Design:
Experimental verification of Robustness for real time applications

POs met through Topics beyond syllabus/Advanced topics/Design: **1,2,3**

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Self- learning such as use of NPTEL materials and internets
CD5	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	3	-
CO2	3	3	3	3	2	3
CO3	3	3	3	3	2	-
CO4	3	3	-	3	3	-
CO5	3	3	3	3	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcome	Course Delivery Method
CO1	CD1,CD2,CD4
CO2	CD1,CD2,CD4
CO3	CD1,CD2,CD3,CD4,CD5
CO4	CD1,CD2,CD3,CD4,CD5
CO5	CD1,CD2,CD3,CD4,CD5