ANNA UNIVERSITY, CHENNAI
UNIVERSITY DEPARTMENTS
REGULATIONS – 2015
CHOICE BASED CREDIT SYSTEM
M.E. INSTRUMENTATION ENGINEERING

PROGRAM EDUCATIONAL OBJECTIVES

1. To lay a strong foundation in Applied mathematics, Instrumentation, Process control and Allied subjects

2. To develop among the students, the competence to analyze systems, develop models, design controllers and configure automation systems

3. To give an overview of principles of operation and comparative study of sensors, transducers and analyzers.

4. To impart practical knowledge in process control and design of instrumentation systems.

5. To prepare students' to work in interdisciplinary areas.

6. To prepare students' to have successful career in industry / R&D organization and academic institutions.

PROGRAM OUTCOMES

a) Ability to solve non-linear algebraic, differential and partial differential equations numerically.
b) Gain expertise to formulate first principles / Data driven models, analyze models, design and implement conventional and advanced control schemes.
c) To be capable of analyzing the characteristics, merits and demerits of various instruments used for measuring key process variables.
d) To get competency in the selection of appropriate instruments their maintenance and calibration.
e) To be able to design and fabricate instrumentation systems to meet the desired specifications.
f) To get acquainted with various Industrial Data Communication protocols, Network Security and Signal Processing Techniques for Process Monitoring and Diagnosis.
g) To gain expertise in the interpretation of Simulation/Experimental results, Technical presentation, documentation and report writing.
h) Gain confidence to provide solutions to Industrial/Research problems and to develop innovative / indigenous products.

PEO		POs						
	a	b	c	d	e	f	g	h
1	√	√	√			√		
2	√	√					√	
3			√	√	√	√		
4				√	√		√	
5				√	√	√		√
6		√	√	√	√		√	√

			PO-a	PO-b	PO-c	PO-d	PO-e	PO-f	PO-g	PO-h
YEAR - 1	SEM 1	Advanced Numerical Methods	✓	✓				✓		✓
		Transducers and Smart Instruments			✓	✓	✓			
		Linear and Nonlinear System Theory	✓	✓					✓	✓
		Multivariable Process Control	✓	✓					✓	✓
		Advanced Digital Signal Processing and its Applications	✓					✓		✓
		Advanced Instrumentation Systems			✓	✓	✓			✓
		Process Control Laboratory	✓	✓	✓				✓	
	SEM 2	Advanced Process Control	✓	✓					✓	✓
		Instrumentation System Design			✓	✓	✓	✓	✓	✓
		Elective I								
		Elective II								
		Elective III								
		Instrumentation System Design Laboratory			✓	✓	✓	✓	✓	✓
		Industrial Automation Laboratory	✓	✓	✓			✓	✓	
YEAR - 2	SEM 3	Elective IV								
		Elective V								
		Elective VI								

Attested

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		Project Work Phase I	✓	✓					✓	✓
	SEM 4	Project Work Phase II	✓	✓						

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ANNA UNIVERSITY, CHENNAI
UNIVERSITY DEPARTMENTS
REGULATIONS – 2015
CHOICE BASED CREDIT SYSTEM
M.E. INSTRUMENTATION ENGINEERING
CURRICULA AND SYLLABI I TO IV SEMESTERS

SEMESTER - I

S.No	Course Code	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	MA7102	Advanced Numerical Methods	FC	4	4	0	0	4
2.	IN7101	Advanced Digital Signal Processing and its Applications	PC	3	3	0	0	3
3.	IN7102	Advanced Instrumentation Systems	PC	3	3	0	0	3
4.	IN7103	Linear and Nonlinear Systems Theory	PC	3	3	0	0	3
5.	IN7104	Multivariable Process Control	PC	3	3	0	0	3
6.	IN7105	Transducers and Smart Instruments	PC	3	3	0	0	3
PRACTICALS								
7.	IN7111	Process Control Laboratory	PC	4	0	0	4	2
			TOTAL	**23**	**19**	**0**	**4**	**21**

SEMESTER - II

S.No	Course Code	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	IN7201	Advanced Process Control	PC	3	3	0	0	3
2.	IN7202	Instrumentation System Design	PC	3	3	0	0	3
3.		Elective-I	PE	3	3	0	0	3
4.		Elective-II	PE	3	3	0	0	3
5.		Elective-III	PE	3	3	0	0	3
PRACTICALS								
6.	IN7211	Industrial Automation Laboratory	PC	4	0	0	4	2
7.	IN7212	Instrumentation System Design Laboratory	PC	4	0	0	4	2
			TOTAL	**23**	**15**	**0**	**8**	**19**

SEMESTER - III

S.No	Course Code	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.		Elective-IV	PE	3	3	0	0	3
2.		Elective-V	PE	3	3	0	0	3
3.		Elective-VI	PE	3	3	0	0	3
PRACTICALS								
4.	IN7311	Project Work Phase I	EEC	12	0	0	12	6
			TOTAL	**21**	**9**	**0**	**12**	**15**

SEMESTER - IV

Sl. No	Course Code	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
PRACTICALS								
1.	IN7411	Project Work Phase II	EEC	24	0	0	24	12
			TOTAL	**24**	**0**	**0**	**24**	**12**

TOTAL NO. OF CREDITS: 67

Attested

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FOUNDATION COURSES (FC)

S.No	Course Code	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.		Advanced Numerical Methods	FC	4	4	0	0	4

PROFESSIONAL CORE (PC)

S.No	Course Code	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.		Transducers and Smart Instruments	PC	3	3	0	0	3
2.		Advanced Instrumentation Systems	PC	3	3	0	0	3
3.		Linear and Nonlinear Systems Theory	PC	3	3	0	0	3
4.		Multivariable Process Control	PC	3	3	0	0	3
5.		Advanced Digital Signal Processing and its Applications	PC	3	3	0	0	3
6.		Process Control Laboratory	PC	4	0	0	4	2
7.		Advanced Process Control	PC	3	3	0	0	3
8.		Instrumentation System Design	PC	3	3	0	0	3
9.		Industrial Automation Laboratory	PC	4	0	0	4	2
10.		Instrumentation System Design Laboratory	PC	4	0	0	4	2

PROFESSIONAL ELECTIVES (PE)

S.No	Course Code	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	CO7074	Robust Control	PE	3	3	0	0	3
2.	IN7001	Adaptive Control	PE	3	3	0	0	3
3.	IN7002	Advanced Image Processing	PE	3	3	0	0	3
4.	IN7003	Advanced Operating System	PE	3	3	0	0	3
5.	IN7004	Applied Biomedical Instrumentation	PE	3	3	0	0	3
6.	IN7005	Bio Signal Processing	PE	3	3	0	0	3
7.	IN7006	Cryptography and Network Security	PE	3	3	0	0	3

8.	IN7007	Fault Tolerant Control	PE	3	3	0	0	3
9.	IN7008	Industrial Data Communication	PE	3	3	0	0	3
10.	IN7009	Industrial Drives and Control	PE	3	3	0	0	3
11.	IN7010	Instrumentation in Petrochemical Industry	PE	3	3	0	0	3
12.	IN7011	Machine Learning	PE	3	3	0	0	3
13.	IN7012	Optimal Control	PE	3	3	0	0	3
14.	IN7013	Real Time Embedded System	PE	3	3	0	0	3
15.	IN7014	State and Parameter Estimation	PE	3	3	0	0	3
16.	IN7015	Thermal Power Plant Instrumentation	PE	3	3	0	0	3
17.	IN7016	VLSI System Design	PE	3	3	0	0	3
18.	IN7017	Wireless Sensor Networks	PE	3	3	0	0	3

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S.No	Course Code	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.		Project Work Phase I	EEC	12	0	0	12	6
2.		Project Work Phase II	EEC	24	0	0	24	12

MA7102 ADVANCED NUMERICAL METHODS

L	T	P	C
4	0	0	4

COURSE OBJECTIVES

- To make the students understand the methods/algorithms to numerically solve set of simultaneous algebraic equations
- To make the students understand the methods to numerically solve set of simultaneous ordinary differential equations
- To make the students understand the methods to numerically solve partial differential equations

UNIT I ALGEBRAIC EQUATIONS 12

Systems of linear equations: Gauss Elimination method, pivoting techniques, Thomas algorithm for tridiagonal system – Jacobi, Gauss Seidel, SOR iteration methods - Systems of nonlinear equations: Fixed point iterations, Newton Method, Eigenvalue problems: power method, inverse power method, Faddeev – Leverrier Method.

UNIT II ORDINARY DIFFERENTIAL EQUATIONS 12

Runge Kutta Methods for system of IVPs, numerical stability, Adams-Bashforth multistep method, solution of stiff ODEs, shooting method, BVP: Finite difference method, orthogonal collocation method, orthogonal collocation with finite element method, Galerkin finite element method

UNIT III FINITE DIFFERENCE METHOD FOR TIME DEPENDENT PARTIAL DIFFERENTIAL EQUATION 12

Parabolic equations: explicit and implicit finite difference methods, weighted average approximation - Dirichlet and Neumann conditions – Two dimensional parabolic equations – ADI method; First order hyperbolic equations – method of characteristics, different explicit and implicit methods; numerical stability analysis, method of lines – Wave equation: Explicit scheme- Stability of above schemes

12

UNIT IV FINITE DIFFERENCE METHODS FOR ELLIPTIC EQUATIONS

Laplace and Poisson's equations in a rectangular region: Five point finite difference schemes, Leibmann's iterative methods, Dirichlet and Neumann conditions – Laplace equation in polar coordinates: finite difference schemes – approximation of derivatives near a curved boundary while using a square mesh.

UNIT V FINITE ELEMENT METHOD 12

Partial differential equations – Finite element method - orthogonal collocation method, orthogonal collocation with finite element method, Galerkin finite element method.

TOTAL: 60 PERIODS

COURSE OUTCOMES

- Ability to solve numerically set of simultaneous algebraic equations
- Ability to solve numerically set of simultaneous ordinary differential equations (IVP)
- Ability to solve numerically set of Partial differential equations

REFERENCE BOOKS

1. Saumyen Guha and Rajesh Srivastava, “Numerical methods for Engineering and Science”,Oxford Higher Education, 2010.
2. R. L. Burden and J. D. Faires, “Numerical Analysis; Theory and Applications”, India Edition, Cengage Learning, 2010.
3. Santosh K Gupta, “Numerical Methods for Engineers”, New Age International (P) Limited,Publishers, 1995.
4. Mahinder Kumar Jain, S.R.K Iyengar, R.K.Jain, Computational Methods for Partial Differential Equations, New Age International, 1994.
5. K.W.Morton, and D.F.Mayers, “Numerical Solution of Partial Differential Equations, Cambridge University Press, Second Edition, 2005.

IN7101	ADVANCED DIGITAL SIGNAL PROCESSING AND ITS APPLICATIONS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To give an overview of Advanced Digital Signal Processing subject with conceptual clarity.
- To provide the foundation for signal modeling, linear prediction and estimation theory.
- To impart knowledge on adaptive filter design, multi-rate signal processing and filter banks.

UNIT I REVIEW OF DIGITAL SIGNALS, SYSTEMS AND FILTERS 9

Discrete Time Fourier Transform – Frequency response of LTI systems - Discrete Fourier Transform - Fast Fourier Transform algorithms: Decimation in time and decimation in frequency algorithm - Digital filters: FIR filter, IIR filter.

UNIT II RANDOM SIGNAL PROCESSING AND SPECTRUM ESTIMATION 9

Discrete random processes - Expectation, Variance, Parseval's Theorem, Wiener Khintchine Relation - Power spectral density - Periodogram – Sample autocorrelation - Sum decomposition theorem, Spectral factorization theorem - Non-parametric methods - Correlation method - Co-variance estimator - Consistent estimators -Periodogram estimator - Barlett spectrum estimation - Welch estimation - Model based approach - AR, MA, ARMA signal modeling - Parameter estimation using Yule-Walker method.

UNIT III LINEAR ESTIMATION AND PREDICTION 9

Maximum likelihood criterion - efficiency of estimator - Least mean squared error criterion - Wiener filter - Discrete Wiener Hoff equations - Recursive estimators - Kalman filter - Linear prediction, prediction error - whitening filter, inverse filter - Levinson recursion, Lattice realization, and Levinson recursion algorithm for solving Toeplitz system of equations.

UNIT IV ADAPTIVE FILTERS 9

FIR adaptive filters - Newton's steepest descent method - Adaptive filter based on steepest descent method - Widrow Hoff LMS adaptive algorithm - Adaptive channel equalization - Adaptive echo chancellor - Adaptive noise cancellation - RLS adaptive filters - Exponentially weighted RLS - Sliding window RLS - Simplified IIR LMS adaptive filter.

UNIT V MULTIRATE DIGITAL SIGNAL PROCESSING 9

Mathematical description of change of sampling rate - Interpolation and Decimation - continuous time model - Direct digital domain approach - Decimation by an integer factor - Interpolation by an integer factor - Single and multistage realization - poly phase realization - Application to sub band coding - Wavelet transform and filter bank implementation of wavelet expansion of signals.

TOTAL : 45 PERIODS

COURSE OUTCOMES

- Ability to apply the knowledge of mathematics, science, and engineering for the analysis and design of digital systems.
- Ability to identify, formulate and solve engineering problems in the area of random signal processing and spectrum estimation.
- Ability to design adaptive filters with realistic constraints.

REFERENCE BOOKS

1. J.G.Proakis and D.G.Manolakis, " Digital Signal Processing: Principles, Algorithms and Applications ", 4th Edition, Pearson Prentice-Hall of India, 2007.
2. Monson H.Hayes, "Statistical Digital Signal Processing and Modeling ", Wiley India, 2008.
3. P. P. Vaidyanathan, “Multirate Systems and Filter Banks”, Prentice Hall Signal Processing Series, Pearson, 2004.
4. Tulay Adali and Simon Haykin, “Adaptive Signal Processing, Next Generation Solutions”, John Wiley and Sons, 2010.
5. Ali Ahammad Shoukat Choudhury, Sirish L. Shah and Nina F.Thornhill, “Diagnosis of Process Nonlinearities and Valve Stiction: Data Driven Approaches”, Springer, 2008.

IN7102 ADVANCED INSTRUMENTATION SYSTEMS

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

- To make the students review the instruments used for measurement of basic process parameters like level, flow, pressure and temperature.
- To explore the various types of analyzers used in industrial applications.
- To make the students aware of basic concepts of safety instrumented system, standards and risk analysis techniques
- To make students familiarize with Instrumentation standards such as BS1042, ISA 75, ISA 84 and ISA 88.
- To make students familiarize with Instrumentation Symbols, Abbreviations and Identification for Instruments ,Process Flow diagrams, Instrument Loop diagrams, Instrument Hookup diagrams and Piping and Instrumentation Diagrams

UNIT I MEASUREMENT OF PROCESS PARAMETERS 9

Measurement of temperature, pressure, flow and level – application - selection – calibration methods.

UNIT II INSTRUMENTS FOR ANALYSIS 9

Ion selective electrodes - Gas & Liquid Chromatography - Oxygen analyzers for gas and liquid –CO,CO_2 ,NO and SO Analyzers- Hydrocarbon and H_2S Analyzers – Dust, smoke, Toxic gas and radiation monitoring.

UNIT III SAFETY INSTRUMENTATION 9

Introduction to Safety Instrumented Systems – Hazards and Risk – Process Hazards Analysis (PHA) – Safety Life Cycle – Control and Safety Systems - Safety Instrumented Function - Safety Integrity Level (SIL) – Selection, Verification and Validation.

UNIT IV INSTRUMENTATION STANDARDS 9

Instrumentation Standards - significance of codes and standards – overview of various types - Introduction of various Instrumentation standards – review, interpretation and significance of specific standards - examples of usage of standards on specific applications.

UNIT V DOCUMENTATION IN PROCESS INDUSTRIES 9

Block Diagram of a Typical Process – Instrumentation Symbols, Abbreviations and Identification for Instruments: - Mechanical Equipment, Electrical Equipment, Instruments and Automation Systems - Process Flow Diagram (PFD) – Piping and Instrumentation Diagram (P&ID) - Instrument Lists and Specification – Logic Diagrams – Instrument Loop Diagrams - Instrument Hookup Diagrams – Location Plans for Instruments - Cable Routing Diagrams – Typical Control /Rack Rooms Layout – Vendors Documents and Drawings

TOTAL: 45 PERIODS

COURSE OUTCOMES

students will be able to

- understand the instrumentation behind flow, level, temperature and pressure measurement
- acquire basic knowledge on the various types of analyzers used in typical industries.
- understand the role of Safety instrumented system in the industry.
- explain Standards for applying Instrumentation in Hazards Locations.
- Design, develop, and interpret the documents used to define instruments and control systems for a typical project, including P&IDs, loop diagrams, specification forms, instrument lists, logic diagrams, installation details, and location plans

REFERENCE BOOKS

1 B.G.Liptak, “Instrumentation Engineers Handbook (Process Measurement & Analysis)”, Fourth Edition, Chilton Book Co, CRC Press, 2005.

2 Al.Sutko,Jerry.D.Faulk, “Industrial Instrumentation”, Delmar publishers, 1996.

3 Paul Gruhn, P.E., CFSE and Harry Cheddie, P.E., “Safety Instrumented Systems: Design, Analysis, and Justification”, 2nd Edition, ISA,2006.

4 Safety - ANSI/ISA84.00.01-2004, Part 1: Framework, Definitions, System Hardware and Software Requirements; ANSI/ISA84.00.01-2004, Part 2: Functional Safety: Safety Instrumented Systems for the Process Industry Sector; ANSI/ISA84.00.01-2004, Part 3: Guidance for the Determination of the Required Safety Integrity Levels-Informative.

5 Standards - ANSI/ISA-75.01.01 -2002 (60534-2-1 Mod): Flow Equations for Sizing control Valves; ISA84 Process Safety Standards and User Resources, Second Edition, ISA, 2011; ISA88 Batch Standards and User Resources, 4th Edition, ISA, 2011.

6 Documentation Standards - ANSI/ISA5.4-1991 - Instrument Loop Diagrams; ANSI/ISA5.06.01-2007 - Functional Requirements Documentation for Control Software Applications; ANSI/ISA20-1981 - Specification Forms for Process Measurement and Control Instruments, Primary Elements, and Control Valves.

		L	T	P	C
IN7103	**LINEAR AND NONLINEAR SYSTEMS THEORY**	**3**	**0**	**0**	**3**

COURSE OBJECTIVES

- To develop the skills needed to represent the system in state space form
- To impart knowledge required to design state feedback controller and state observers
- To impart knowledge and skills needed to classify singular points and construct phase trajectory using delta and isocline methods.
- To make the students understand the concepts of stability and introduce techniques to assess the stability of certain class of non-linear system using describing function, Lyapunov Stability, Popov’s Stability Criterion and Circle Criterion
- To make the students understand the various non-linear behaviors such as Limit cycles, input multiplicity and output multiplicity, Bifurcation and Chaos.

UNIT I STATE SPACE APPROACH 9

Review of state model for systems – No uniqueness of state model - Role of Eigen values and Eigenvectors - State transition matrix and its properties – free and forced responses – State Diagrams - minimal realization – balanced realization.

UNIT II STATE FEEDBACK CONTROL AND STATE ESTIMATOR 9

Controllability and observability – Stabilizability and Detectability - Kalman Decomposition - State Feedback – Pole placement technique – Full order and Reduced Order Observers

UNIT III NON-LINEAR SYSTEMS 9

Types of Non-Linearity – Typical Examples – Singular Points - Phase plane analysis (analytical and graphical methods) – Limit cycles – Equivalent Linearization – Describing Function Analysis, Derivation of Describing Functions for different non-linear elements.

UNIT IV STABILITY OF NON-LINEAR SYSTEMS 9

Stability concepts – Equilibrium points – BIBO and Asymptotic stability – Stability Analysis by DF method – Lyapunov Stability Criteria – Krasovskil's method – Variable Gradient Method – Popov's Stability Criterion – Circle Criterion

UNIT V NON-LINEAR SYSTEMS ANALYSIS 9

Bifurcation Behavior of Single ODE Systems: - Motivation, Illustration of Bifurcation Behavior and Types of Bifurcations - Bifurcation Behavior of Two-State Systems: - Dimensional Bifurcations in the Phase-Plane, Limit Cycle Behavior and Hopf Bifurcation - Introduction to Chaos: The Lorenz Equations, Stability Analysis of the Lorenz Equations, Numerical Study of the Lorenz Equations, Chaos in Chemical Systems and Other Issues in Chaos

TOTAL :45 PERIODS

COURSE OUTCOMES

- Ability to represent the time-invariant systems in state space form as well as analyze, whether the system is stabilizable, controllable, observable and detectable.
- Ability to design state feedback controller and state observers
- Ability to classify singular points and construct phase trajectory using delta and isocline methods.
- Use the techniques such as describing function, Lyapunov Stability, Popov's Stability Criterion and Circle Criterion to assess the stability of certain class of non-linear system.
- Ability to describe non-linear behaviors such as Limit cycles, input multiplicity and output multiplicity, Bifurcation and Chaos.

REFERENCE BOOKS

1 K.Ogata, "Modern Control Engineering", Prentice Hall, Fifth Edition, 2012.

2 M.Gopal, "Digital Control and State Variable Methods: Conventional and Intelligent Control Systems", Third Edition, Tata Mc-Graw Hill, 2009.

3 B.W.Bequette, "Process Control: Modeling, Design and Simulation", Prentice Hall International series in Physical and Chemical Engineering Sciences, 2003.

4 Steven E. LeBlanc, Donald R. Coughanowr, "Process Systems Analysis and Control", Third Edition, Chemical Engineering series, McGraw-Hill Higher Education, 2009

IN7104 MULTIVARIABLE PROCESS CONTROL

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

- To give an overview of the features associated with Industrial Type PID Controller such as reset windup, bumpless auto-manual transfer, proportional kick and derivative kick.
- To make the students understand the various PID tuning methods
- To elaborate different types of control schemes such as cascade control, feed-forward control, DMC, GPC, Inferential control schemes, Multi-variable control schemes etc.

UNIT I PROCESS DYNAMICS 9

Need for process control – Hierarchical decomposition of Control Functions - Continuous and batch processes – P&ID diagram - Self regulation - Interacting and non-interacting systems - Mathematical model of Level, Flow and Thermal processes – Lumped and Distributed parameter models – Linearization of nonlinear systems – System Identification-motivation and overview - Non-parametric methods:- Impulse response, step response and Frequency response methods, correlation and spectral analysis methods.

UNIT II CONTROL ACTIONS, PID CONTROLLER TUNING – SINGLE LOOP REGULATORY CONTROL 9

Characteristic of ON-OFF, P, P+I, P+D and P+I+D control modes – Digital PID algorithm – Auto/manual transfer - Reset windup – Practical forms of PID Controller – PID types Fuzzy Controller -Evaluation criteria – IAE, ISE, ITAE and ¼ decay ratio.

Tuning: - Process reaction curve method:- Z-N and Cohen-Coon methods, Continuous cycling method and Damped oscillation method – optimization methods – Auto tuning –Tuning PID Controller using Fuzzy Logic.

UNIT III ENHANCEMENT TO SINGLE LOOP REGULATORY CONTROL & MODEL BASED CONTROL SCHEMES 9

Cascade control – Split-range - Feed-forward control – Ratio control – Inferential control –– override control - Smith predictor control scheme - Internal Model Controller - IMC PID controller – Single Loop Dynamic Matrix Control – Generalized Predictive Control.

UNIT IV MULTIVARIABLE SYSTEMS & MULTI-LOOP REGULATORY CONTROL 9

Multivariable Systems – Transfer Matrix Representation – Poles and Zeros of MIMO System - Multivariable frequency response analysis - Directions in multivariable systems - Singular value decomposition - Multi-loop Control - Introduction – Process Interaction – Pairing of Inputs and Outputs -The Relative Gain Array (RGA) – Properties and Application of RGA - Multi-loop PID Controller – Biggest Log Modulus Tuning Method - Decoupling Control.

UNIT V MULTIVARIABLE REGULATORY CONTROL & CASE –STUDIES 9

Introduction to Multivariable control – Multivariable PID Controller -Multivariable IMC – Multivariable Dynamic Matrix Controller - Multiple Model based Predictive Controller –Predictive PID Control - Control Schemes for Distillation Column, CSTR, Bioreactor, Four-tank system, pH, and polymerization reactor.

TOTAL :45 PERIODS

COURSE OUTCOMES

- Ability to Apply knowledge of mathematics, science, and engineering to the build and analyze models for flow, level, and thermal processes
- Ability to determine the advanced Features supported by the Industrial Type PID Controller.
- Ability to Design, tune and implement SISO P/PI/PID Controllers to achieve desired Performance for various processes
- Ability to Analyze Multivariable Systems and Design Multi-variable and Multi-loop Control Schemes for various processes namely four-tank system, pH process, bio-reactor, distillation column
- Ability to Identify, formulate, and solve problems in the process control domain

REFERENCE BOOKS

1 B.Wayne Bequette, "Process Control: Modeling, Design, and Simulation", Prentice Hall of India, 2004.

2 Dale E. Seborg , Duncan A. Mellichamp , Thomas F. Edgar, and Francis J. Doyle, III "Process Dynamics and Control", John Wiley and Sons, 3rd Edition, 2010.

3 Jose A. Romagnoli and Ahmet Palazoglu , "Introduction to Process Control", CRC Press, Taylor and Francis Group, Second Edition, First Indian Reprint, 2012.

4 Coleman Brosilow and Babu Joseph, "Techniques of Model-based Control", Prentice Hall International Series, PTR, New Jersey, 2002.

IN7105	**TRANSDUCERS AND SMART INSTRUMENTS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES

- To give a detailed knowledge on transducer characteristics and uncertainties in measurement
- To provide a detailed knowledge on error and determination of uncertainties in measurement.
- To give a comprehensive knowledge on smart sensor Design, Development and Challenges.
- To give exposure to manufacturing techniques and different types of Micro sensors and actuators
- To give an overview of latest advancement and trend in transducer systems.

UNIT I OVERVIEW OF CONVENTIONAL TRANSDUCERS AND ITS CHARACTERISTICS **9**

Overview of conventional sensors - Resistive, Capacitive, Inductive, Piezoelectric, Magnetostrictive and Hall effect sensors - Static and Dynamic Characteristics and specifications.

UNIT II MEASUREMENT ERROR AND UNCERTAINTY ANALYSIS 9

Importance of error analysis - Uncertainties, precision and accuracy in measurement - Random errors - Distributions, mean, width and standard error - Uncertainty as probability - Gaussian and Poisson probability distribution functions, confidence limits, error bars, and central limit theorem - Error propagation - single and multi-variable functions, propagating error in functions - Data visualization and reduction - Least square fitting of complex functions

.

UNIT III SMART SENSORS 9

Definition – Integrated smart sensors - Interface electronics - Design, sensing elements and parasitic effects, ADC, Accuracy and Dynamic range - Universal Sensor Interface – converters - front end circuits DAQ – Design - Digital conversion techniques - Microcontrollers and digital signal processors for smart sensors – selection - Timer, Analog comparator, ADC and DAC modules - Standards for smart sensor interface.

UNIT IV MICRO SENSORS AND ACTUATORS 9

Micro system design and fabrication – Micro pressure sensors (Piezo resistive and Capacitive) – Resonant sensors – Acoustic wave sensors – Bio micro sensors – Micro actuators – Micro mechanical motors and pumps- Introduction to Nano sensors.

UNIT V RECENT TRENDS IN SENSOR TECHNOLOGIES 9

Thick film and thin film sensors- Electro chemical sensors – RFIDs - Sensor arrays - Sensor network - Multisensor data fusion - Soft sensor.

TOTAL : 45 PERIODS

COURSE OUTCOMES

- Will be able to completely characterize a conventional transducer.
- Can confidently analyze and quantify the uncertainties in measurement data.
- Will have the capability to design and develop customized smart sensors.
- Acquire a comprehensive Knowledge of manufacturing techniques and design aspects of micro sensors and actuators
- Get exposure to latest sensor technology and advanced measurement Methodologies.

REFERENCE BOOKS

1 Ernest O Doebelin and Dhanesh N Manik, "Measurement Systems Application and Design", 5thEdition, Tata Mc-Graw Hill, 2011.

2 Ifan G. Hughes and Thomas P.A. Hase, Measurements and their Uncertainties: A Practical Guide to Modern Error Analysis, Oxford University Press, 2010.

3 Gerord C.M. Meijer, Smart Sensor Systems, John Wiley and Sons, 2008.

4 Tai-Ran Hsu, Mems and Micro Systems: Design and Manufacture, Tata McGraw Hill, 2002.

5 D. Patranabis, "Sensors and Transducers", Second Edition, PHI, 2004.

IN7111 **PROCESS CONTROL LABORATORY**

L	T	P	C
0	0	4	2

COURSE OBJECTIVES

To impart theoretical and practical skills in

- Process Identification
- Tuning of PID controller including Auto-tuning
- PID Enhancements and
- Design of advanced control schemes such as Gain Scheduled PID Controller, Fuzzy Logic Controller and Model Predictive Controller

1. (i) Study of a Process Control Training plant

   (ii) Determination of characteristics of a Pneumatically Actuated

   Control valve with and Without Positioner.
2. Simulation of Lumped Parameter System.
3. Simulation of Distributed Parameter System.
4. Identification of Transfer function model of a Typical Industrial Process using non-parametric identification methods.
5. Design and Implementation of Practical Forms of PID Controller on the simulated model of a Typical Industrial Process.
6. Design and Implementation of a PID Control scheme on the simulated model of a Typical Industrial Process.
7. Design and Implementation of Relay Auto-Tuning of PID controller on the simulated model of a Typical Industrial Process.
8. Design and Implementation of Feed forward and Cascade control schemes on the simulated model of a Typical Industrial Process.
9. (a) Analysis of MIMO system.

   (b) Design and implementation of Multi-loop PID and Multivariable PID control schemes on the simulated model of a Typical Industrial Process.
10. Design and implementation of Gain scheduled Adaptive controller on the simulated model of a variable area tank process.
11. Design and implementation of a Dynamic Matrix Control scheme on the simulated model of a Typical Industrial Process.

12. Design and implementation of a Fuzzy Logic Control scheme on the simulated model of a Typical Industrial Process.

TOTAL : 60 PERIODS

COURSE OUTCOMES

- Gain hands on experience in working with SKID mounted pilot plants (Flow/Level/Temperature/ Pressure Control Loop(s))
- Get exposed to simulation tools such as MATLAB/LABVIEW/ASPEN.
- Be able to build dynamic models using the input-output data of a process.
- Get acquainted with PID implementation issues and be able to tune the PID controller.
- Ability to obtain servo and regulatory responses and be able to analyze and draw meaningful conclusions.
- Be able to design and implement Feed-forward, cascade control scheme, simple adaptive control scheme and model based control scheme.

IN7201	ADVANCED PROCESS CONTROL	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To teach students to build and analyze models for time-varying systems and non-linear systems.
- To develop the skills needed to design adaptive controllers such as gain-scheduled adaptive controller, Model-reference adaptive controller and Self-tuning controller for various applications
- To make the students learn to formulate optimal control schemes
- To provide basic knowledge about Fractional-order systems and Fractional-order-controller and to lay the foundation for the systematic approach to Design controller for fractional order systems
- To introduce FDI Techniques, such as Principal component Analysis, state observer to detect and diagnose faults in sensors and actuators.

UNIT I CONTROL OF TIME-VARYING AND NONLINEAR SYSTEMS 9

Models for Time-varying and Nonlinear systems – Input signal design for Identification –Real-time parameter estimation – Model Validation - Types of Adaptive Control - Gain scheduling - Adaptive Control - Deterministic Self-tuning Controller and Model Reference Adaptive Controller – Control of Hammerstein and Wiener Systems

Attested

DIRECTOR
Centre For Academic Courses
Anna University, Chennai-600 025.

UNIT II OPTIMAL CONTROL & FILTERING **9**

Introduction – Performance Measure for optimal control problem – Dynamic Programming – Computational Procedure for solving Control Problem – LQR – Introduction to Optimal Filtering – Discrete Kalman Filter – LQG

UNIT III FRACTIONAL ORDER SYSTEM & CONTROLLER **9**

Fractional-order Calculus and Its Computations – Frequency and Time Domain Analysis of Fractional-Order Linear Systems - Filter Approximations to Fractional-Order Differentiations – Model reduction Techniques for Fractional Order Systems –Controller Design Studies for Fractional Order

UNIT IV H-INFINITY CONTROLLER **9**

Introduction – Norms for Signals – Robust Stability – Robust Performance – Small Gain Theorem – Optimal H_2 Controller Design - H-Infinity Controller Design –– Effects of Weighting Functions in H-Infinity Control.

UNIT V FAULT DIAGNOSIS AND FAULT-TOLERANT CONTROL **9**

Process Monitoring - Introduction – Statistical Process Control – Fault Detection with Principal Component Analysis – Fault Detection with State Observers – Fault Detection with signal models - Fault Detection of Control Loops- Sensor and Actuator Fault-Tolerant Control Design

TOTAL :45 PERIODS

COURSE OUTCOMES

- Ability to Apply knowledge of mathematics, science, and engineering to build and analyze models for time-varying systems and non-linear systems.
- Ability to design and implement adaptive controllers such as gain-scheduled adaptive controller, Model-reference adaptive controller and Self-tuning controller
- Ability to Identify, formulate, and solve optimal controller
- Ability to Analyze Fractional-order systems, Fractional-order- controller and Design controller for fractional order systems
- Ability to design and implement H_2 and H-infinity Controllers
- Ability to use the FDI Techniques, such as Principal component Analysis, state observer to detect and diagnose faults in sensors and actuators.

REFERENCE BOOKS

1 K.J. Astrom and B.J.Wittenmark, “Adaptive Control”, Pearson Education, Second Edition, 2008.

2 Donald E.Kirk, "Optimal Control Theory – An Introduction", Dover Publications, Inc. Mineola, New York, 2012

3 D.Xue, Y.Q.Chen, D.P.Atherton, "Linear Feedback Control Analysis and Design with MATLAB, Advances In Design and Control", Society for Industrial and Applied Mathematics, 2008.

4 R. Isermann, "Fault-Diagnosis Systems: An Introduction from Fault Detection to Fault Tolerance", Springer, 2006.

IN7202 INSTRUMENTATION SYSTEM DESIGN

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

- To impart knowledge on the design of signal conditioning circuits for the measurement of Level, temperature and pH.
- To develop the skills needed to design, fabricate and test Analog/ Digital PID controller, Data Loggers and Alarm Annunciator
- To make the students familiarize design orifice and control valve sizing.

UNIT I DESIGN OF SIGNAL CONDITIONING CIRCUITS 9

Design of V/I Converter and I/V Converter- Analog and Digital filter design and Adaptive filter design – Signal conditioning circuit for pH measurement, Air-purge Level Measurement – Signal conditioning circuit for Temperature measurement: Thermocouple, RTD and Thermistor - Cold Junction Compensation and Linearization – software and Hardware approaches

UNIT II DESIGN OF TRANSMITTERS 9

Study of 2 wire and 4 wire transmitters – Design of RTD based Temperature Transmitter, Thermocouple based Temperature Transmitter, Capacitance based Level Transmitter and Smart Flow Transmitters.

UNIT III DESIGN OF DATA LOGGER AND PID CONTROLLER 9

Design of ON / OFF Controller using Linear Integrated Circuits - Electronic PID Controller – Microcontroller Based Digital Two-degree of freedom PID Controller - Micro - controller based Data Logger – Design of PC based Data Acquisition Cards

UNIT IV ORIFICE AND CONTROL VALVE SIZING 9

Orifice, Venturi and flow nozzle Sizing: - Liquid, Gas and steam services – Control valve sizing – Liquid, Gas and steam Services – Rotameter Design.

UNIT V DESIGN OF ALARM AND ANNUNCIATION CIRCUIT 9

Alarm and Annunciation circuits using Analog and Digital Circuits – Design of Programmable Logic Controller - Design of configurable sequential controller using PLDs

TOTAL : 45 PERIODS

COURSE OUTCOMES

- Ability to design signal conditioning circuits for temperature sensors, V/I and I/V converters
- Ability to design and fabricate smart transmitters
- Ability to design, fabricate and test PID controllers and alarm circuits
- Ability to carry out orifice and control valve sizing for Liquid/Steam Services

REFERENCE BOOKS

1 C. D. Johnson, "Process Control Instrumentation Technology", 8th Edition, Prentice Hall, 2014.
2 Control Valve Handbook, 4th Edition, Emerson Process Management, Fisher Controls International, 2005.
3 R.W. Miller, "Flow Measurement Engineering Handbook", Mc-Graw Hill, New York 1996.
4 Bela G. Liptak, "Instrument Engineers Handbook - Process Control and Optimization", 4th Edition, Vol.2, CRC Press,2008.
5 Thakore and Bhatt ,"Introduction to Process Engineering and Design" , TATA McGraw-Hill,2007.

IN7211	**INDUSTRIAL AUTOMATION LABORATORY**	**L**	**T**	**P**	**C**
		0	**0**	**4**	**2**

COURSE OBJECTIVES

To teach the importance of measurement for monitoring, control and to impart theoretical and practical skills in

- Sensor Data acquisition, Data analysis, Data processing and Data visualization.
- Interpretation of Piping & Instrumentation Diagrams
- Interfacing Conventional and Smart Field Devices (Transmitters & Control Valves) with Industrial Type Distributed Control System
- Programming of Industrial Type Programmable Logic Controller (Ladder Logic and Function Block Programming)
- Understanding the Instruction set of Programmable Logic Controller.

1. Interpretation of P & ID (ISA s5.1)
2. Control of flow process using multi-loop PID controller.
3. Interfacing data acquisition card with personal computer.
4. Control of thermal process using embedded controller.
5. PC based control of level process.
6. On-line monitoring and control of a pilot plant using an industrial type distributed control system.
7. Simple exercises using the Instruction Set of Industrial Type Programmable Logic Controller.

8. Programmable logic controller exercises
    i. Filling/draining control operation
    ii. Reversal of dc motor direction
    iii. Traffic light control

9. Control of level process using industrial type programmable logic controller.

10. Speed & position control of a DC servo motor

11. Control of an inverted pendulum.

12. Design and implementation of advanced control scheme on the skid mounted pilot plant.

TOTAL : 60 PERIODS

COURSE OUTCOMES

- Get acquainted with Control Loop Hardware and Trouble Shooting.
- Ability to experimentally measure Industrial process parameters/variables such as flow, level, temperature and pressure.
- Ability to configure a Industrial Type Single /Multi-loop PID Controller
- Gain hands on experience in working with Industrial Type Distributed Control System and be able to Configure Function Blocks and develop Feedback and Cascade Control Strategies using Function Blocks.
- Ability to Interface Transmitters (Smart- HART enabled /Conventional/FF Enabled) and Control valves (Conventional/FF Enabled) with Industrial Type DCS.
- Ability to monitor and Control a pilot plant using Industrial Type DCS (Centralized Monitoring & Decentralized Control).
- Ability to realize the Discrete Control Sequence in Industrial Type PLC using Ladder Logic and Function Block Programming
- Get exposed to the basics of speed & Position control of servo-motor.

IN7212	INSTRUMENTAION SYSTEM DESIGN LABORATORY	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES

- This laboratory will provide exposure and adequate knowledge in the design of various signal conditioning circuits.
- This enables them to develop various modules for final year project as per industrial standards and practices.

1. Design, Fabrication and Testing of 2-wire Analog Transmitter.
2. Design, Fabrication and Testing of 4-wire Analog Transmitter.
3. Design, Fabrication and Testing of 2-wire Smart Transmitter.

4. Design, Fabrication and Testing of Data Logger.
5. Design, Fabrication and Testing of Analog PID Controller.
6. Design, Fabrication and Testing of Digital PID Controller.
7. Design, Fabrication and Testing of Alarm, Annunciation Circuits.
8. Development of Software Package for sizing Orifice.
9. Development of Software Package for sizing Control Valve.
10. Development of Software Package for sizing Rotameter.
11. Design of Programmable Logic Controller using Microcontroller.
12. Design of ON/OFF Controller for Thermal Process.

TOTAL : 60 PERIODS

COURSE OUTCOMES

- The students will be able to design conventional and smart transmitters.
- They will be able to design On/Off controllers, PID controllers and PLC based controllers
- They will be able to design data loggers and alarm circuits.
- They will be able to develop software packages for sizing control vale, orifice and rotameter.

CO7074 ROBUST CONTROL LT P C 3 0 0 3

COURSE OBJECTIVES

- To introduce norms, random spaces and robustness measures To educate on H_2 optimal control and estimation techniques.
- To educate on Hinfinity optimal control techniques To educate on the LMI approach of Hinfinity control.
- To educate on synthesis techniques for robust controllers and illustrate through case studies.

UNIT I INTRODUCTION 9

Norms of vectors and Matrices – Norms of Systems – Calculation of operator Norms – vector Random spaces- Specification for feedback systems – Co-prime factorization and Inner functions –structured and unstructured uncertainty- robustness.

UNIT II H_2 OPTIMAL CONTROL 9

Linear Quadratic Controllers – Characterization of H_2 optimal controllers – H_2 optimal estimation-Kalman Bucy Filter – LQG Controller.

UNIT III H-INFINITY OPTIMAL CONTROL-RICCATI APPROACH 9

Formulation – Characterization of H-infinity sub-optimal controllers by means of Riccati equations – H-infinity control with full information – Hinfinity estimation

UNIT IV H-INFINITY OPTIMAL CONTROL- LMI APPROACH 9

Formulation – Characterization of H-infinity sub-optimal controllers by means of LMI Approach – Properties of H-infinity sub-optimal controllers – H-infinity synthesis with pole-placement constraints

UNIT V SYNTHESIS OF ROBUST CONTROLLERS & CASE STUDIES 9

Synthesis of Robust Controllers – Small Gain Theorem – D-K –iteration- Control of Inverted Pendulum- Control of CSTR – Control of Aircraft – Robust Control of Second-order Plant-Robust Control of Distillation Column

TOTAL : 45 PERIODS

COURSE OUTCOME

- Ability to understand the structured and unstructured uncertainty of robustness.
- Ability to design a H_2 optimal controller and to implement kalman Bucy filter .
- Ability to design a H-Infinity optimal control using Riccati and LMI Approach.
- Will be able to synthesis the Robust Controller and small gain theorem.
- Ability to implement a robust Controller for CSTR and Distillation Column.

REFERENCES

1. U. Mackenroth "Robust Control Systems: Theory and Case Studies",Springer International Edition, 2010.
2. J. B. Burl, " Linear optimal control H2 and H-infinity methods", Addison W Wesley, 1998
3. D. Xue, Y.Q. Chen, D. P. Atherton, "Linear Feedback Control Analysis and Design with MATLAB, Advances In Design and Control", Society for Industrial and Applied Mathematics, 2007.
4. I.R. Petersen, V.A. Ugrinovskii and A. V. Savkin, "Robust Control Design using H-infinity Methods", Springer, 2000.
5. M. J. Grimble, "Robust Industrial Control Systems: Optimal Design Approach for Polynomial Systems", John Wiley and Sons Ltd., Publication, 2006.

IN7001	ADAPTIVE CONTROL	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To impart knowledge on how to recursively estimate the parameters of discrete input – output models (ARX/ARMAX etc) using recursive parameter estimation methods

- To make the student understand the principles of STR, MRAC and Gain scheduling.
- To make the student design simple adaptive controllers for linear systems using above methods

UNIT I INTRODUCTION 9

Introduction - Adaptive Schemes - The adaptive Control Problem – Applications - Real-time parameter estimation: - Least squares and regression methods- Estimating parameters in dynamical systems

UNIT II GAIN SCHEDULING 9

Introduction- The principle - Design of gain scheduling controllers- Nonlinear transformations - application of gain scheduling - Auto-tuning techniques: Methods based on Relay feedback

UNIT III DETERMINISTIC SELF-TUNING REGULATORS 9

Introduction- Pole Placement design - Indirect Self-tuning regulators - direct self-tuning regulators – Disturbances with known characteristics

UNIT IV STOCHASTIC AND PREDICTIVE SELF-TUNING REGULATORS 9

Introduction – Design of minimum variance controller - Design of moving average controller - stochastic self-tuning regulators

UNIT V MODEL – REFERENCE ADAPTIVE SYSTEM ATIONS 9

Introduction- MIT rule – Determination of adaptation gain - Lyapunov theory –Design of MRAS using Lyapunov theory – Relations between MRAS and STR.

TOTAL : 45 PERIODS

COURSE OUTCOMES

- Will be able to design simple adaptive controllers for linear systems.
- Ability to identify, formulate, analyse the implementation of adaptive controllers t engineering problems.

REFERENCE BOOKS

1 K.J. Astrom and B. J. Wittenmark, “Adaptive Control”, Second Edition, Pearson Education Inc., 1995.
2 T. Soderstorm and Petre Stoica, “System Identification”, Prentice Hall International(UK) Ltd., 1989.
3 N.Mathivanan, ”PC-based Instrumentation Concepts and Practice”, Eastern Economy Edition, PHI Learning private ltd ,2009
4 Lennart Ljung, “System Identification: Theory for the User”, Second Edition, Prentice Hall, 1999.

IN7002 ADVANCED IMAGE PROCESSING

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

- To introduce the image fundamentals and transforms
- To impart knowledge in image enhancement
- To give exposure to image restoration and image compression
- To familiarize the students on image analysis
- To make the students to understand the concept of pattern recognition

UNIT I IMAGE FUNDAMENTALS AND TRANSFORMS 9

Elements of Digital image processing systems-Digital image representation- visual perception-Sampling, Quantization, Image basis function- Two dimensional DFT- Discrete cosine transform –Walsh-Hadamard transform-Wavelet transform-Principal Component Analysis-Color image Processing.

UNIT II IMAGE ENHANCEMENT 9

Basic grey level transformation –Contrast stretching - Histogram equalization – Image subtraction – Image averaging –Spatial filtering: Smoothing, sharpening filters – Laplacian filters – Frequency domain filters: Smoothing – Sharpening filters – Homomorphic filtering - Morphological Operations.

UNIT III IMAGE RESTORATION AND COMPRESSION 9

Image restoration-Degradation model-Unconstrained and Constrained restoration –Inverse filtering – Wiener filter-Restoration in spatial domain-Image Compression-Transform coding-Vector Quantization-Hierarchical and progressive compression methods

UNIT IV IMAGE ANALYSIS 9

Boundary detection based techniques, Point, line detection, Edge detection, Edge linking, local processing, regional processing, Hough transform, Thresholding methods, Moving averages, Multivariable thresholding, Region-based segmentation, Watershed algorithm.

UNIT V PATTERN RECOGNITION 9

Recognition based on Decision Theoretic methods-Structural Recognition- Linear Discriminant Analysis – Baye's Classifier – Neural net- Fuzzy system – Optimization Techniques in Recognition - Applications in particle size measurement – Flow measurement - Food processing – Case studies.

TOTAL : 45 PERIODS

COURSE OUTCOMES

- Be able to apply image enhancement, image compression, restoration techniques, image segmentation approaches.
- Ability to apply image processing techniques in both the spatial and frequency domains.
- Be capable of applying image processing algorithms to real problems.

REFERENCE BOOKS

1. Rafael C.Gonzalez and Richard E.Woods, “Digital Image Processing” Prentice Hall, Third Edition, 2010.
2. William K.Pratt, “Digital Image Processing”, Wiley-Interscience, Fourth Edition, 2007.
3. Rafael C.Gonzalez and Richard E.Woods, “Digital Image Processing using MATLAB”, Gatesmark Publishing, Second Edition, 2010.
4. M. Sonka, V.Hlavac and R.Boyle, “Image Processing Analysis and Machine Vision”, CL Engineering, Third Edition, 2007.
5. A.K. Jain, “Fundamentals of Digital Image Processing”, Prentice Hall, First Edition,1989.

IN7003	ADVANCED OPERATING SYSTEM	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To introduce fundamental concepts and mechanisms of advanced operating system.
- To provide a basic foundation in the design of operating system.
- To provide various alternative approaches to the solution of the problems encountered in the design of operating system.

UNIT I OPERATING SYSTEM 9

Introduction – operating systems and services – CPU scheduling approaches – Process synchronization semaphores – Deadlocks – Handling deadlocks – Multithreading.

UNIT II DISTRIBUTED SYSTEMS 9

Introduction – Advantages of distributed system over centralized system, Limitations of distributed system, Communication in distributed systems – ATM, Client-Server model distributed operating system – Issues, Communication primitives – Message passing model, Remote procedure call.

UNIT III SYNCHRONIZATION IN DISTRIBUTED SYSTEMS 9

Clock synchronization – Lamport’s logical clock, Vector clock, Causal ordering of messages, Causal ordering of messages, Mutual exclusion – Non token based and token based algorithm, Atomic transactions, Distributed deadlock detection and prevention.

UNIT IV DISTRIBUTED RESOURCE MANAGEMENT 9

Distributed file system – Trend, design and implementation, Distributed Shared Memory (DSM) – Memory coherence, Page based DSM, Shared variable DSM, Object based DSM, Distributed scheduling.

UNIT V FAILURE RECOVERY AND FAULT TOLERANCE 9

Recovery – Classification, Backward and forward error recovery, Recovery in concurrent systems, synchronous check pointing and recovery, Check pointing for Distributed database system, Fault tolerant – commit protocols, Voting protocols, Dynamic vote reassignment protocol, Failure Resilient processes.

TOTAL : 45 PERIODS

COURSE OUTCOMES

- Ability to have the knowledge of distributed operating systems.
- Ability to implement the state of art techniques to address the various design issues in advanced operating system.

REFERENCE BOOKS

1. ukesh Singhal and Niranjan G. Shivaratri, "Advanced Concepts in Operating Systems", Tata McGraw Hill, 2001.
2. Abraham Silberschatz, Peter B. Galvin and Greg Gagne, "Operating Systems Concepts", John Wiley, Eighth edition, 2008.
3. William Stallings, "Operating Systems: Internals and Design Principles", Pearson Education, Seventh edition, 2011.
4. Andrew S. Tanenbaum, "Distributed Operating Systems", Pearson Education, 1995.

IN7004	APPLIED BIOMEDICAL INSTRUMENTATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To introduce the principles and design issues of biomedical instrumentation
- To understand the nature and complexities of biomedical measurements

UNIT I INTRODUCTION TO BIOMEDICAL MEASUREMENTS 9

Physiological systems and measurable variables- Nature and complexities of biomedical measurements- Medical equipment standards- organization, classification and regulation- Biocompatibility - Human and Equipment safety – Physiological effects of electricity, Micro and macro shocks, thermal effects.

UNIT II ADVANCES IN MODELING AND SIMULATIONS IN BIOMEDICAL INSTRUMENTATION 9

Modeling and simulation in Biomedical instrumentation – Difference in modeling engineering systems and physiological systems – Model based analysis of Action Potentials - cardiac output – respiratory mechanism - Blood glucose regulation and neuromuscular function.

UNIT III BIOMEDICAL SIGNALS AND THEIR ACQUISITIONS 9

Types and Classification of biological signals – Signal transactions – Noise and artifacts and their management - Biopotential electrodes- types and characteristics - Origin, recording schemes and analysis of biomedical signals with typical examples of Electrocardiography(ECG), Electroencephalography(EEG), and Electromyography (EMG)– Processing and transformation of signals-applications of wavelet transforms in signal compression and denoising.

UNIT IV INSTRUMENTATION FOR DIAGNOSIS AND MONITORING 9

Advanced medical imaging techniques and modalities -Instrumentation and applications in monitoring and diagnosis- Computed tomography, Magnetic Resonance Imaging and ultrasound- Algorithms and applications of artificial intelligence in medical image analysis and diagnosis-Telemedicine and its applications in telemonitoring.

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UNIT V BIOMEDICAL IMPLANTS AND MICROSYSTEMS 9

Implantable medical devices: artificial valves, vascular grafts and artificial joints- cochlear implants - cardiac pacemakers – Microfabriation technologies for biomedical Microsystems-microsensors for clinical applications – biomedical microfluid systems

TOTAL:45 PERIODS

COURSE OUTCOMES

- Ability to apply fundamental principles for designing and modelling biomedical systems.
- Ability to use mathematical/computational tools for biomedical image and signal analysis

REFERENCE BOOKS

1 John G.Webster, “Bioinstrumentation”, John Wiley & Sons, 2008.
2 Shayne C.Gad, “Safety Evaluation of Medical Devices”, CRC Press, Second Edition, 2002.
3 Michael C.K.Khoo, “Physiological Control Systems: Analysis, Simulation and Estimation, IEEE Press, 2000.
4 John G.Webster, “Medical Instrumentation Application and Design”, John Wiley & Sons, Third Edition, 2009.
5 L.Cromwell, Fred J.Weibell and Erich A.Pfeiffer, “Biomedical Instrumentation and Measurements”, Prentice Hall of India, Digitized 2010.
6 P.Strong, “Biophysical Measurements”, Tektronix, Digitized 2007.
7 K.Najarian and R. Splinter, “Biomedical Signal and Image Processing”, CRC Press, 2012.
8 John L.Semmlow, “Biosignal and Biomedical Image Processing”, CRC Press, First Edition, 2004.
9 Joseph J.Carr and John M.Brown, “Introduction to Biomedical Equipment Technology”, Prentice Hall, Fourth Edition, 2004.

IN7005	BIOSIGNAL PROCESSING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To introduce fundamental, theoretical and methodological principles of biosignal processing and analysis
- To estimate parametric models of the measured biosignals for prediction, simulation and diagnostic purposes

UNIT I INTRODUCTION TO SIGNALS 9

Sources of Biomedical signals, types of signals – Deterministic, stochastic, fractal and chaotic, auto correlation, cross correlation, auto covariance, DFT, FFT algorithm – Digital filters – Introduction to FIR and IIR filter.

UNIT II CLASSICAL SPECTRAL ESTIMATION TECHNIQUES 9

Periodogram, Blackman – Tukey spectral Estimation applications – analysis of the Doppler signal using the Periodogram, analysis of Auditory Evoked potentials (AEP) using periodogram, analysis of Heart rate variability using the periodogram cepstrum anlaysis – Cepstra, power cepstrum, applications of cepstrum analysis – analysis of the ECG signal using cepstrum technique, analysis of Diastolic Heart sound using cepstrum technique.

UNIT III ADAPTIVE NOISE CANCELLATION 9

Introduction, principle of adaptive noise canceling, adaptive Noise cancellation with the LMS and RLS adaptation algorithm - applications – adaptive noise canceling method to enhance ECG monitoring, adaptive noise canceling method to enhance Fetal ECG monitoring, adaptive noise canceling method to enhance Electro gastric measurements.

UNIT IV PARAMETRIC MODELING METHODS 9

Autoregressive (AR) methods – Linear Prediction and Autoregressive methods, the autocorrelation (Yule - walker) methods, applications of AR methods AR modeling of seizure EEG, ECG signals and surface EMG. Autoregressive Moving Average (ARMA) method – MLE method, Akaike method, Durbin method, applications – ARMA modeling of somatosensory Evoked Potentials (SEPs), Diastolic Heart sounds and cutaneous Electro gastric signals.

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UNIT V NON LINEAR BIOSIGNAL PROCESSING AND WAVELET TRANSFORM 9

Clustering methods – hard and fuzzy clustering, applications of Fuzzy clustering to Biomedical signal processing, Neural Networks – Introduction – NN in processing and analysis of Biomedical signals wavelet transform – Introduction, Filter bank implementation of discrete wavelet transform, signal Denoising using wavelet transform, wavelet based compression.

TOTAL : 45 PERIODS

COURSE OUTCOMES

- Ability to estimate suitable models of the measured biosignals
- Ability to use mathematical/computational tools for biomedical image and signal analysis

REFERENCE BOOKS

1 M.Akay, “Biomedical Signal Processing”, Academic Press, San Diego, 2001.

2 M.Akay, “Nonlinear Biomedical Signal Processing”, Fuzzy Logic, Neural Networks and New Algorithms, vol.1, IEEE Press Series on Biomedical Engineering, New York, 2000.

3 Eugene N.Bruce, “Biomedical Signal Processing and Signal Modeling”, John Wiley & Sons, First Edition, 2007.

IN7006 CRYPTOGRAPHY AND NETWORK SECURITY

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

- To introduce mathematical foundations for cryptography.
- To familiarize symmetric and asymmetric cryptography ciphers.
- To highlight the features of integrity, authentication, digital signature and key management.
- To introduce the network security concepts.

UNIT I MATHEMATICAL BACKGROUND OF CRYPTOGRAPHY 9

Introduction, Integer arithmetic, modular arithmetic, Linear congruence, Number theory, Algebraic structures, GF(2^n) fields, Primes, Primality testing, Factorization, Chinese remainder theorem, Quadratic congruence, Exponentiation and Logarithm.

UNIT II SYMMETRIC KEY CRYPTOGRAPHY 9

Introduction, Substitution cipher, Transposition cipher, Stream cipher, Block cipher, DES – Structure, Analysis, Security of DES, AES – Transformations, Key expansion, Evaluation, Cipher, Analysis, Modern Symmetric Key Cipher – Use of modern block ciphers, Use of stream ciphers.

UNIT III ASYMMETRIC KEY CRYPTOGRAPHY, KEY MANAGEMENT 9

Introduction, RSA cryptosystem, Rabin cryptosystem, ElGamal Cryptosystem, Eliptic curve cryptosystem, Key management – Symmetric key distribution, Kerberos, Symmetric key agreement, Public key distribution, Hijacking.

UNIT IV INTEGRITY, DIGITAL SIGNATURE, AUTHENTICATION 9

Integrity – Message integrity, Random Oracle model, Message authentication, Hash function – Introduction, Message digest, Secure hash function, Digital Signature – Introduction, Attacks, Schemes, Variations and Applications, Entity authentication – Introduction, Passwords, Challenge-response, Zero knowledge, Biometrics.

UNIT V NETWORK SECURITY 9

Security at application layer – Email, PGP, S/MIME, Security at transport layer – SSL architecture, Four protocols, SSL message format, transport layer security, Security at network layer – Two modes, Two security protocols, Security association, Security policy, Internet key exchange.

TOTAL : 45 PERIODS

COURSE OUTCOMES

- Use of mathematical foundations in cryptography applications.
- Ability to use symmetric and asymmetric key cryptography algorithms in real applications.
- Ability to identify problems and solutions of integrity, authentication, key management.

- Ability to implement digital signature and to analyze security in networks.

REFERENCE BOOKS

1. Douglas R.Stinson, "Cryptography: Theory and Practice", Chapman and Hall, Third Edition, 2006.
2. Wenbo Mao, "Modern Cryptography: Theory and Practice", Pearson Education, 2008.
3. Neal Koblitz, "A Course in Number Theory and Cryptography", Springer, Second Edition, 1998.
4. A.J.Menezes, Paul C.Van Oorschot and Scott A.Vanstone, "Handbook of Applied Cryptography", CRC Press, First Indian Reprint, 2010.

IN7007	FAULT TOLERANT CONTROL	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To give an overview of different Fault Detection and Diagnosis methods
- To impart knowledge and skills needed to design and detect sensor and actuators faults using structured residual approach as well as directional structured residual approach
- To impart knowledge and skills needed design and detect faults in sensor and actuators using GLR and MLR based Approaches
- To present an overview of various types of fault tolerant control schemes such as Passive and active approaches
- To impart knowledge and skills needed to detect and quantify and compensate stiction in Control valves

UNIT I INTRODUCTION & ANALYTICAL REDUNDANCY CONCEPTS 9

Introduction - Types of faults and different tasks of Fault Diagnosis and Implementation - Different approaches to FDD: Model free and Model based approaches-Introduction-Mathematical representation of Faults and Disturbances: Additive and Multiplicative types – Residual Generation: Detection, Isolation, Computational and stability properties – Design of Residual generator – Residual specification and Implementation

UNIT II DESIGN OF STRUCTURED RESIDUALS & DIRECTIONAL STRUCTURED RESIDUALS 9

Introduction- Residual structure of single fault Isolation: Structural and Canonical structures-Residual structure of multiple fault Isolation: Diagonal and Full Row canonical concepts – Introduction to parity equation implementation and alternative representation - Directional Specifications: Directional specification with and without disturbances – Parity Equation Implementation

UNIT III FAULT DIAGNOSIS USING STATE ESTIMATORS 9

Introduction – State Observer – State Estimators – Norms based residual evaluation and threshold computation - Statistical methods based residual evaluation and threshold settings: Generalized Likelihood Ratio Approach – Marginalized Likelihood Ratio Approach

UNIT IV FAULT TOLERANT CONTROL 9

Introduction – Passive Fault-tolerant Control- Active Fault tolerant Control - Actuator and Sensor Fault tolerance Principles:- Compensation for actuator – Sensor Fault-tolerant Control Design – Fault-tolerant Control Architecture - Fault-tolerant Control design against major actuator failures.

UNIT V CASE STUDIES 9

Fault tolerant Control of Three-tank System – Diagnosis and Fault-tolerant control of chemical process – supervision of steam generator – Different types of faults in Control valves – Automatic detection, quantification and compensation of valve stiction

TOTAL : 45 PERIODS

COURSE OUTCOMES

- Ability to Explain different approaches to Fault Detection and Diagnosis
- Ability to design and detect sensor and actuators faults using structured residual approach as well as directional structured residual approach
- Ability to design and detect faults in sensor and actuators using GLR and MLR based Approaches
- Ability to explain various types of fault tolerant control schemes such as Passive and active approaches
- Ability to Design fault-tolerant control scheme in the presence of actuator failures
- Ability to detect and quantify and compensate stiction in Control valves

REFERENCE BOOKS

1 Janos J. Gertler, “Fault Detection and Diagnosis in Engineering systems” –2nd Edition, Marcel Dekker, 1998.

2 Rolf Isermann, Fault-Diagnosis Systems an Introduction from Fault Detection to Fault Tolerance, Springer Verlag, 2006.

3 Steven X. Ding, Model based Fault Diagnosis Techniques: Schemes, Algorithms, and Tools, Springer Publication, 2012.

4 Hassan Noura, Didier Theilliol, Jean-Christophe Ponsart, Abbas Chamseddine, Fault-Tolerant Control Systems: Design and Practical Applications, Springer Publication, 2009.

5. Mogens Blanke, Diagnosis and Fault-Tolerant Control, Springer, 2006.

6. Ali Ahammad Shoukat Choudhury, Sirish L. Shah, Nina F. Thornhill, Diagnosis of Process Nonlinearities and Valve Stiction: Data Driven Approaches, Springer, 2008.

IN7008 INDUSTRIAL DATA COMMUNICATION

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

- To give an overview of the Industrial data communications systems
- To provide a fundamental understanding of common principles, various standards, protocols
- To provide insight into some of the new principles those are evolving for future networks.

UNIT I DATA NETWORK FUNDAMENTALS 9

EIA 232 interface standard – EIA 485 interface standard – EIA 422 interface standard – Serial interface converters - ISO/OSI Reference model – Data link control protocol – Media access protocol:-Command/response, Token passing and CSMA/CD - TCP/IP – Bridges – Routers – Gateways –Standard ETHERNET Configuration

UNIT II PLC, PLC PROGRAMMING & SCADA 9

Evolutions of PLCs – Programmable Controllers – Architecture – Comparative study of Industrial PLCs. –PLC Programming:- Ladder logic, Functional block programming, Sequential function chart, Instruction list and Structured text programming. SCADA:- Remote terminal units, Master station, Communication architectures and Open SCADA protocols.

UNIT III DISTRIBUTED CONTROL SYSTEM & HART 9

Evolution - Different architectures - Local control unit - Operator Interface – Displays - Engineering interface - Study of any one DCS available in market - Factors to be considered in selecting DCS – Case studies in DCS. Introduction- Evolution of signal standard – HART communication protocol – Communication modes – HART Networks – HART commands – HART applications – MODBUS protocol structure – Function codes – Troubleshooting

UNIT IV PROFIBUS AND FF 9

Fieldbus:- Introduction, General Fieldbus architecture, Basic requirements of Fieldbus standard, Fieldbus topology, Interoperability and Interchangeability Profibus:- Introduction, Profibus protocol stack, Profibus communication model, Communication objects, System operation and Troubleshooting – Foundation fieldbus versus Profibus.

UNIT V AS – INTERFACE (AS-i), DEVICENET AND INDUSTRIAL ETHERNET 9

AS interface:- Introduction, Physical layer, Data link layer and Operating characteristics.
Devicenet:- Introduction, Physical layer, Data link layer and Application layer. Industrial Ethernet:- Introduction, 10Mbps Ethernet and 100Mbps Ethernet - Introduction to OLE for process control

TOTAL:45 PERIODS

COURSE OUTCOMES

- Ability to develop an understanding of and be able to select and use most appropriate technologies and standards for a given application
- Ability to design and ensuring that best practice is followed in installing and commissioning the data communications links to ensure they run fault-free

REFERENCE BOOKS

1 T.A. Hughes, “Programmable Logic Controllers: Resources for Measurements and Control Series”, Third edition, ISA Press, 2004.
2 R.Bowden, “HART Application Guide”, HART Communication Foundation, 1999.
3 G.K.McMillan, “Process/Industrial Instrument and Controls Handbook”, Fifth Edition, McGraw-Hill handbook, New York, 1999.
4 J.Berge, “Field Buses for Process Control: Engineering, Operation, and Maintenance”, ISA Press, 2004.
5 S.Mackay, E.Wright, D.Reynders, and J.Park, “Practical Industrial Data Networks: Design, Installation and Troubleshooting”, Newnes Publication, Elsevier, 2004.
6 W.Buchanan, “Computer Busses: Design and Application”, CRC Press, 2000.
7 F.D.Petruzella, “Programmable Logic Controllers”, Third Edition, Tata McGraw-Hill, 2010.
8 M.P.Lucas, “Distributed Control System”, Van Nostrand Reinhold Company, New York, 1986.
9 G.Clarke, D.Reynders and E.Wright, “Practical Modern SCADA Protocols: DNP3, IEC 60870.5 and Related Systems”, Newnes, First Edition, 2004.

IN7009	**INDUSTRIAL DRIVES AND CONTROL**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES

- To give an overview on fundamental aspects of motor-load systems and basic characteristics of dc and ac drives.
- To introduce various modeling methods of dc and ac drives.
- To give detailed knowledge on operation, analysis and control of converter and chopper driven dc drives
- To give exposure to principle, techniques of conventional control of ac drives
- To introduce advanced control strategies of ac drives and latest developments in the field of control of electric drives.

UNIT I INTRODUCTION TO ELECTRIC DRIVES 9

Motor-Load system–Dynamics, load torque, steady state stability, Multi quadrant operations of drives. DC motors- speed reversal, speed control and breaking techniques, Characteristics of Induction motor and Synchronous motors-Dynamic and regenerative braking ac drives.

UNIT II MODELING OF DC AND AC MACHINES 9

Circuit model of Electric Machines-Transfer function and State space models of series and separately excited DC motor-AC Machines –Dynamic modeling –linear transformations-equations in stator, rotor and synchronously rotating reference frames-flux linkage equations-Dynamic state space model-modeling of Synchronous motor

UNIT III CONTROL OF DC DRIVES 9

Analysis of series and separately excited DC motor with single phase and Three phase converters operating in different modes and configurations- Analysis of series and separately excited DC motor fed from different choppers,-two quadrant and four quadrant operation-Closed loop control of dc drives-Design of controllers

UNIT IV CONTROL OF AC DRIVES 9

Operation of induction motor with non-sinusoidal supply waveforms, Variable frequency operation of 3-phase inductions motors, constant flux operation, current fed operations, Constant torque operations, Static rotor resistance control and slip power recovery scheme –Synchronous motor control, control of stepped motors, Parameter sensitivity of ac drives.

UNIT V ADVANCED CONTROL OF AC DRIVES 9

Principles of vector control –Direct and indirect vector control of induction motor –DTC- sensor less vector control-speed estimation methods-Applications of Fuzzy logic and Artificial Neural Network for the control of AC drives.

TOTAL : 45 PERIODS

COURSE OUTCOMES

Students

- Get a thorough understanding of motor-load system dynamics and stability, modern drive system objectives and fundamentals of dc and ac motors.
- Will have the ability to model both dc and ac motors in various conventional methods.
- Confidently design and analyze both converter and chopper driven dc drives
- Will have a thorough understanding of conventional control techniques of ac drives and will have the ability to design and analyze such system
- Get a detailed knowledge on advanced high performance control strategies for ac drives and emerging technologies in electric drives.

REFERENCE BOOKS

1 G.K.Dubey, “Power Semiconductor Controlled Drives,” Prentice Hall International, New Jersey, 1989.

2 Paul .C.Krause, Oleg wasynczuk and Scott D.Sudhoff, “Analysis of Electric Machinery and Drive Systems”, 2nd edition , Wiley-IEEE Press, 2013.

3 Bimal K Bose, “Modern Power electronics and AC Drives”, Pearson education Asia, 2002.

4 R .Krishnan, “Electrical Motor Drives- Modeling, Analysis and Control”, Prentice Hall of India Pvt Ltd., 2nd Edition, 2003.

IN7010 INSTRUMENTATION IN PETROCHEMICAL INDUSTRY

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

To enable students to acquire knowledge about

- The different methods of crude oil recovery, processing and refining
- Important Unit operations in petroleum refinery and petrochemical industry
- Production routes of important petrochemicals, and
- Control of selected petrochemicals production processes.
- Hazards and therefore the necessary safety measure in planning and function of petrochemical Industry.

UNIT I OIL EXTRACTION AND PROCESSING 9

Techniques used for oil discovery:-seismic survey - methods of oil extraction - oil rig system – Primary, Secondary and Enhanced oil recovery - separation of gas and water from oil - control loops in oil gas separator - scrubber – coalescer.

UNIT II PETROLEUM REFINING 9

Petroleum refining process - unit operations in refinery: - thermal cracking - catalytic cracking - catalytic reforming - polymerization - isomerization - alkylation - Production of ethylene, acetylene and propylene from petroleum.

UNIT III CHEMICALS FROM PETROLEUM 9

Chemicals from methane, acetylene, ethylene and propylene - production routes of important petrochemicals such as polyethylene, polypropylene, ethylene dioxide, methanol, xylene, benzene, toluene, styrene, VCM and PVC.

UNIT IV CONTROL LOOPS IN PETROCHEMICAL INDUSTRY 9

Control of binary and fractional distillation columns - Control of catalytic and thermal crackers - control of catalytic reformer - control of alkylation process - Control of polyethylene production – Control of VCM and PVC production.

UNIT V SAFETY IN INSTRUMENTATION SYSTEM 9

Area and material classification as per National Electric Code (NEC) - Classification as per International Electro technical Commission (IEC) - Techniques used to reduce explosion hazards - Pressurization techniques - Type X, Type Y and Type Z - Intrinsic safety - Mechanical and Electrical isolation - Lower and Upper explosion limit.

TOTAL:45 PERIODS

COURSE OUTCOME

After completing this course the student will:

- Gain basic knowledge about the methodologies applied for recovery and processing of petroleum.
- Be familiar with different unit operations involved in Petroleum industry.
- Have a general understanding of the production routes for important petrochemicals.

- Be able to describe the control of important processes like FCCU, Catalytic Reformer, Alkylation.
- Be able to classify the hazardous zones and gain knowledge about the techniques used to reduce the explosion hazards.

REFERENCE BOOKS

1. Jens G. Balchen, Kenneth I. Mummé, Process Control: Structures and Applications, Von Nostrand Reinhold Company, New York, 1999.
2. Håvard Devold, "Oil and Gas Production Handbook-An Introduction to Oil and Gas Production" ABB ATPA Oil and Gas, 2006.
3. Béla G. Lipták, "Instrumentation in Process Industries", Chilton Book Company, 2005.
4. Austen Lawrence Waddams, "Chemical from Petroleum", Butter and Janner Ltd., 1978.
5. Ram Prasad, Petroleum Refining Technology, Khanna Publishers, New Delhi, 2000.

IN7011	**MACHINE LEARNING**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES

- To give an introduction on several fundamental concepts and methods for machine learning.
- To familiarize with some basic learning algorithms and techniques and their applications.
- To provide the knowledge related to processing, analyzing and handling data sets.
- To illustrate the typical applications of various clustering based learning algorithms

UNIT I INTRODUCTION TO MACHINE LEARNING 9

Objectives of machine learning – Human learning/ Machine learning – Types of Machine learning:- Supervised Learning – Unsupervised learning – Reinforcement Learning – Evolutionary Learning - Regression – Classification – The Machine Learning Process:- Data Collection and Preparation – Feature Selection – Algorithm Choice – Parameter and Model Selection – Training – Evaluation.

UNIT II DATA PREPROCESSING 9

Data quality – Data preprocessing: - Data Cleaning:– Handling missing data and noisy data – Data integration:- Redundancy and correlation analysis – Data Reduction:- Dimensionality reduction (Linear Discriminant Analysis – Principal Components Analysis – Factor Analysis – Independent Components Analysis) – Numerosity Reduction - Data Compression - Data Normalization and Data Discretization.

UNIT III SUPERVISED LEARNING 9

Linearly separable and nonlinearly separable populations – Multi Layer Perceptron – Backpropagation Learning Algorithm – Radial Basis Function Network – Support Vector Machines: - Kernels – Risk and Loss Functions - Support Vector Machine Algorithm – Multi Class Classification – Support Vector Regression.

UNIT IV CLUSTERING AND UNSUPERVISED LEARNING 9

Introduction – Clustering:- Partitioning Methods:- K-means algorithm - Hierarchical clustering – Fuzzy Clustering – Clustering High-Dimensional Data:- Problems – Challenges – Subspace Clustering – Biclustering - Self Organizing Map (SOM) - SOM algorithm.

UNIT V BAYESIAN LEARNING 9

Probability based clustering – The Expectation Maximization Algorithm – Bayesian Classification – Bayesian Networks – Learning Bayesian Networks – Hidden Markov Models.

TOTAL:45 PERIODS

COURSE OUTCOMES

- Ability to understand the basic theory underlying machine learning.
- Will be able to understand a range of machine learning algorithms along with their strengths and weaknesses.
- Will be able to formulate machine learning problems corresponding to different applications.
- Will be able to apply machine learning algorithms to solve problems of moderate complexity.
- Ability to read current research papers and understand the issues raised by current research.

REFERENCE BOOKS

1 Stephen Marsland, Machine Learning: An Algorithmic Perspective, CRC Press, 2011.

2 Ian H. Witten, Eibe Frank, Mark A. Hall, Data Mining: Practical Machine Learning Tools and Techniques, Elsevier, 2011

3 Jiawei Han, Micheline Kamber, Jian Pei, Data Mining: Concepts and Techniques: Concepts and Techniques, Elsevier, 2011.

4 Ferdinand van der Heijden, Robert Duin, Dick de Ridder, David M. J. Tax, Classification, Parameter Estimation and State Estimation: An Engineering Approach Using MATLAB, John Wiley & Sons, 2005.

IN7012	**OPTIMAL CONTROL**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES

- To give exposure to different type of optimal control problems such as time-optimal, fuel optimal, energy optimal control problems
- To impart knowledge and skills needed to design Linear Quadratic Regulator for Time-

- invariant and Time-varying Linear system (Continuous time and Discrete-time systems)
- To introduce concepts needed to design optimal controller using Dynamic Programming Approach and H-J-B equation.
- To give exposure to various types of fault tolerant control schemes such as Passive and active approaches
- To introduce concepts needed to design optimal controller in the presence of state constraints and time optimal controller

UNIT I CALCULUS OF VARIATIONS AND OPTIMAL CONTROL 9

Introduction – Performance Index- Constraints – Formal statement of optimal control system – Calculus of variations – Function, Functional, Increment, Differential and variation and optimum of function and functional – The basic variational problem Extrema of functions and functionals with conditions – variational approach to optimal control system

UNIT II LINEAR QUADRATIC OPTIMAL CONTROL SYSTEM 9

Problem formulation – Finite time Linear Quadratic regulator – Infinite time LQR system: Time Varying case- Time-invariant case – Stability issues of Time-invariant regulator – Linear Quadratic Tracking system: Fine time case and Infinite time case

UNIT III DISCRETE TIME OPTIMAL CONTROL SYSTEMS 9

Variational calculus for Discrete time systems – Discrete time optimal control systems:- Fixed-final state and open-loop optimal control and Free-final state and open-loop optimal control - Discrete time linear state regulator system – Steady state regulator system

UNIT IV PONTRYAGIN MINIMUM PRINCIPLE 9

Pontryagin Minimum Principle – Dynamic Programming:- Principle of optimality, optimal control using Dynamic Programming – Optimal Control of Continuous time and Discrete-time systems – Hamilton-Jacobi-Bellman Equation – LQR system using H-J-B equation

UNIT V CONSTRAINED OPTIMAL CONTROL SYSTEMS 9

Time optimal control systems – Fuel Optimal Control Systems- Energy Optimal Control Systems – Optimal Control Systems with State Constraints

TOTAL : 45 PERIODS

COURSE OUTCOMES

- Ability to explain different type of optimal control problems such as time-optimal, fuel optimal, energy optimal control problems
- Ability to design Linear Quadratic Regulator for Time-invariant and Time-varying Linear system (Continuous time and Discrete-time systems)
- Ability to design optimal controller using Dynamic Programming Approach and H-J-B equation.
- Ability to Explain the Pontryagin Minimum Principle.
- Ability to design optimal controller in the presence of state constraints and time optimal controller.

REFERENCE BOOKS

1 Donald E. Kirk, Optimal Control Theory – An Introduction, Dover Publications, Inc. Mineola, New York, 2012.

2 D. Subbaram Naidu, Optimal Control Systems, CRC Press, New York, 2003.
3 Frank L. Lewis, Draguna Vrabie, Vassilis L. Syrmos, Optimal Control, 3rd Edition, Wiley Publication, 2012.

IN7013	REAL TIME EMBEDDED SYSTEM	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To introduce the Building blocks of Real Time Embedded System
- To familiarize the embedded hardware components & its interface
- To impart knowledge on embedded software development process
- To make the students understand the Real Time Operating Systems
- To give exposure to the Case studies in various fields

UNIT I INTRODUCTION TO REAL TIME SYSTEMS 9

Fundamentals of systems and real time system - Definitions, classification, Characteristics-Basic model of Real Time Systems – Timing constraints – Safety and Reliability- Typical applications of Real Time Systems.

UNIT II EMBEDDED SYSTEM COMPONENTS AND ITS INTERFACE 9

Embedded system definition- architecture and standards with examples - Embedded hardware-processors-memory devices-Interface and Peripherals- ARM processor based embedded boards - Power and its Management.

UNIT III EMBEDDED SYSTEM SOFTWARE DEVELOPMENT 9

Software embedded in a system – IDE , Assembler, Compiler ,linker, simulator,debugger,In - circuit Emulator(ICE), Target hardware debugging , Program modeling – Program models, Data flow model, State machine programming models, UML models - High level language descriptions in embedded system, Java based embedded system design.

UNIT IV RTOS BASED EMBEDDED SYSTEM DESIGN 9

Introduction to basic concepts of RTOS –Task, Process and Threads, Interrupt routines in RTOS, Multiprocessing & Multitasking, Preemptive and non-Preemptive scheduling, Task communication – shared memory –Inter Process communication – synchronization between processes – semaphores, mail box, pipes, priority Inversion, priority Inheritance, comparison of Real time operating systems: Vxworks, µC/OS II.

UNIT V CASE STUDIES 9

Case studies of Embedded System Design and Coding in application areas of digital consumer electronics , automotives and networking/communication.

TOTAL : 45 PERIODS

COURSE OUTCOMES

- Ability to select embedded hardware components & its interface
- Gain knowledge on embedded software development process
- Acquire knowledge on Real Time Operating Systems
- Gain expertise in the Case studies in various fields

REFERENCE BOOKS

1. T.Noergaard , "Embedded Systems Architecture : A Comprehensive Guide for Engineers and Programmers", Elsevier Publications, 2012.
2. A.S.Berger, "Embedded System Design : An Introduction to Process, Tools and Techniques", CMP Books, 2008.
3. D.D.Gajski, F.Vahid, S.Narayan, "Specification and Design of Embedded Systems", PTR Prentice Hall, 2007.
4. D.E.Simon, "An Embedded Software Primer", Addison Wesley, 2000.
5. Kai Qian, David Den haring, Li Cao, "Embedded Software Development with C", Springer, 2009.

IN7014	**STATE AND PARAMETER ESTIMATION**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES

- To elaborate the concept of estimating the state variables of a system using state estimation algorithms.
- To elaborate the concept of estimating the parameters of the selected models using parameter estimation algorithm
- To make the student understand the principles of closed loop identification
- To make the students understand the use of ANN, Fuzzy Logic, ANFIS for modeling of non-linear system and to get familiarized with the ANN and Fuzzy Logic tool boxes.
- To provide the background on the practical aspects of conducting experiments for real time system identification

UNIT I KALMAN UPDATE BASED FILTERS & PARTICLE FILTER 9

Review of Matrix Algebra and Matrix Calculus and Probability Theory – Least Square Estimation – Review of state observers for Deterministic System - Kalman filter – Extended Kalman filter – Unscented Kalman filter – Ensemble Kalman filter – Particle filter - The H-infinity filter.

UNIT II PARAMETER ESTIMATION METHODS 9

Parametric model structures:-ARX, ARMAX, OE, BJ models - Least squares method, statistical properties of LS Estimates. Weighted Least Squares, Maximum Likelihood Estimation, Prediction error methods and Instrumental variable methods. Recursive Estimation methods – Simultaneous State and Parameter Estimation – Dual State and Parameter Estimation.

UNIT III CLOSED- LOOP IDENTIFICATION 9

Identification of systems operating in closed loop: Identifiability considerations – direct identification – indirect identification - Subspace Identification methods: classical and innovation forms, free and structures parameterizations - Relay feedback identification of stable processes and unstable processes.

UNIT IV NONLINEAR SYSTEM IDENTIFICATION 9

Modeling of non linear systems using ANN- NARX,NNSS,NARMAX - Generation of training data – Training Feed-forward and Recurrent Neural Networks – TSK model – Adaptive Neuro-Fuzzy Inference System(ANFIS) - Introduction to Support Vector Regression

UNIT V PRACTICAL ASPECTS OF IDENTIFICATION 9

Practical aspects: experimental design – input design for identification, notion for persistent excitation, drifts and de-trending – outliers and missing data – pre-filtering - robustness – Model validation and Model structure determination- Case studies.

TOTAL:45 PERIODS

COURSE OUTCOMES

- Ability to design and implement state estimation schemes
- Ability to develop various models (Linear & Nonlinear) from the experimental data
- Will be able to select a suitable model and parameter estimation algorithm for the identification of systems.
- Will be able to carry out the verification and validation of identified model.
- Will gain expertise on using the model for prediction and simulation purposes and for developing suitable control schemes.

REFERENCE BOOKS

1 Dan Simon, "Optimal State Estimation Kalman, H-infinity and Non-linear Approaches", John Wiley and Sons, 2006.

2 Arun K. Tangirala, "Principles of System Identification: Theory and Practice", CRC Press, 2014.

3 F. Van der Heijden, R.P.W. Duin, D. de Ridder and D.M.J. Tax, Classification, Parameter Estimation and State Estimation, An Engineering Approach Using MATLAB, John Wiley & Sons Ltd., 2004.

4 W.T.Miller, R.S.Sutton and P.J.Webrose, "Neural Networks for Control", MIT Press, 1996. C.Cortes and V.Vapnik, "Support-Vector Networks, Machine Learning", 1995.

6 Karel J. Keesman," System Identification an Introduction", Springer, 2011.

7 Tao Liu, Furong Gao, "Industrial Process Identification and control design, Step-test and relay-experiment-based methods", Springer- Verilog London Ltd, 2012.

8 Lennart Ljung, "System Identification: Theory for the user", Second edition, Prentice Hall, 1999.

IN7015 THERMAL POWER PLANT INSTRUMENTATION

L	T	P	C
3	0	0	3

COURSE OBJECTIVE

After completion of the course the students will acquire extensive knowledge about:

- Operation & importance of Instrumentation in Thermal power plant
- Development of Mathematical model of different systems in Thermal power plant
- Conventional and advanced control schemes applied to various processes in Thermal Power Plant
- Measurement of important parameters and control techniques applied to steam turbines
- Calculation and optimization of Boiler efficiency by including various losses in thermal power plant

UNIT I BASICS OF THERMAL POWER PLANT 9

Process of power generation in coal – fired and oil-fired thermal power plants- Types of Boilers- Combustion process – Super heater – Turbine – Importance of Instrumentation in thermal power plants.

UNIT II BOILER MODELING 9

Development of first principle and data driven models:- combustion chamber, boiler drum,superheater and attemperator

UNIT III BOILER CONTROL 9

Combustion control-Air/fuel ratio control-furnace draft control –Drum level control –Steam temperature Control– DCS in power plant – Interlocks in Boiler Operation- Model predictive control of super heater – control of drum level using AI techniques.

UNIT IV TURBINE & ALTERNATOR - MONITORING AND CONTROL 9

Measurement of speed, vibration, shell temperature of steam turbine – Steam pressure Control – Speed control of turbine – Alternator- Monitoring voltage and frequency –Operation of several units in parallel- Synchronization.

UNIT V OPTIMIZATION OF THERMAL POWER PLANT OPERATION 9

Determination of Boiler efficiency – Heat losses in Boiler – Effect of excess air –Optimizing total air supply- Combustible material in ash- Reduction of turbine losses-Choice of optimal plant parameters- Economics of operation.

TOTAL:45 PERIODS

COURSE OUTCOME

- The student will be equipped with the basic knowledge of function of different systems in Thermal power plant
- The student knows the procedural steps to obtain the mathematical model of various units in Thermal power plant
- Will be able to explain conventional and advanced control concepts and theirs implementation in various processes.
- Will get idea on the parameters to be monitored, measured and controlled in steam turbines
- Calculation and optimization of Boiler efficiency by including various losses in thermal power plant

REFERENCE BOOKS

1. A.B.Gill, "Power Plant Performance", Elsevier India, New Delhi , 2013.
2. S.M.Elonko and A.L.Kohal, "Standard Boiler Operations", McGraw Hill, New Delhi, 1994.
3. Sam G. Duke Low, "The Control of Boiler", ISA press, 1991
4. R.K.Jain, "Mechanical and Industrial Measurements", Khanna Publishers, New Delhi, 1995.

IN7016	VLSI SYSTEM DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To introduce the fundamentals of various MOS device characteristics.
- To familiarize the design rules and layout for NMOS and CMOS.
- To give exposure on the design of simple examples using various logic design methods.
- To lay foundation about issues involved in the selection of PLD.
- To impart knowledge on implementation of the above design in VHDL programming environment.

UNIT I BASIC DEVICE CHARACTERISTICS 9

NMOS, PMOS, enhancement and depletion mode transistor, MOSFET threshold voltage, linear and saturated operation, standard CMOS inverter, transit time and switching speed of NMOS and CMOS inverters. Circuit characteristics and performance estimation: delay estimation, transistor sizing, power distribution, scaling, noise margin and latch up.

UNIT II DESIGN RULES AND LAYOUT 9

Purpose of design rules, NMOS and CMOS design rules and layout, Design of NMOS and CMOS inverters, NAND and NOR gates. Stick diagrams and layout of logic gates.

UNIT III VLSI SUBSYSTEM DESIGN 9

Pass Transistor Logic, transmission gate logic, NMOS logic, Static/Dynamic CMOS logic and BiCMOS logic. Design examples: logic gates, multiplexer, flip flop and shift registers.

UNIT IV FPGAs AND CPLDs 9

Introduction to PLDs -PLA, PAL, GAL. FPGA: Architecture, logic element, interconnects technology. CPLD: Architecture, logic array block, Macrocell, PIA Technology. Specific GAL, FPGA and CPLD devices from Altera / Xilinx.

UNIT V PRINCIPLES OF HDL 9

VHDL design Entity- Signal and Variable - Concurrent Assignment Statements – Sequential Assignment Statements – Combinational circuits: Multiplexers, adders, priority encoder. Sequential circuits: different types of flip flops, registers, shift register and counters. An introduction to High level VLSI synthesis and design tools. Realizing PID controller in VHDL.

TOTAL : 45 PERIODS

COURSE OUTCOMES

- Will be able to gain the knowledge of the characteristics and performance of MOS devices.
- Will have an exposure to design of stick diagrams and layout of gates.
- Ability to carry out design of simple circuits using various logic schemes.
- Will be able to select appropriate PLD for an application.
- Will gain expertise in developing and effectively synthesizing VDHL programs for combinational and sequential applications.

REFERENCE BOOKS

1 Jan M.Rabaey, Anantha Chandrakasan and Borivoje Nikolic, “Digital Integrated Circuits – A Design Perspective”, Second Edition, Prentice Hall, 2003.
2 Stephen Brown, Zvonko Vranesic, “Fundamentals of Digital Logic with VHDL Design”, Second edition, McGraw Hill, 2007.
3 Thomas L.Floyd & Jain ,”Digital Fundamentals”, Tenth edition, Pearson Education, 2009
4 John P.Uyemura, “Introduction to VLSI Circuits and Systems”, First Edition, John Wiley and Sons, 2006.
5 Wayne Wolf, “FPGA – Based System Design”, Prentice Hall, 2004.

IN7017	**WIRELESS SENSOR NETWORKS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES

- To introduce the technologies and applications for the emerging domain of wireless sensor networks,
- To impart knowledge on the design and development of the various layers in the WSN protocol stack
- To elaborate the various issues related to WSN implementations
- To familiarize the students with the hardware and software platforms used in the design of WSN

UNIT I INTRODUCTION 9

Challenges for wireless sensor networks, Comparison of sensor network with ad hoc network, Single node architecture – Hardware components, energy consumption of sensor nodes, Network architecture – Sensor network scenarios, types of sources and sinks, single hop versus multi-hop networks, multiple sinks and sources, design principles, Development of wireless sensor networks.

UNIT II PHYSICAL LAYER 9

Wireless channel and communication fundamentals – frequency allocation, modulation and demodulation, wave propagation effects and noise, channels models, spread spectrum communication , packet transmission and synchronization, quality of wireless channels and measures for improvement, physical layer and transceiver design consideration in wireless sensor networks, energy usage profile, choice of modulation,
power management.

UNIT III DATA LINK LAYER 9

MAC protocols –fundamentals of wireless MAC protocols, low duty cycle protocols and wakeup concepts, contention-based protocols, Schedule-based protocols, Link Layer protocols – fundamentals task and requirements ,error control ,framing, link management

UNIT IV NETWORK LAYER 9

Gossiping and agent-based uni-cast forwarding , Energy-efficient unicast, Broadcast and multicast, geographic routing , mobile nodes, Data –centric and content-based networking – Data –centric routing, Data aggregation, Data-centric storage, Higher layer design issue

UNIT V CASE STUDIES 9

Target detection and tracking, Habitat monitoring, Environmental disaster monitoring, Practical implementation issues, IEEE 802.15.4 low rate WPAN, Sensor Network Platforms and tools-Sensor node hardware, Node-level software platforms, node –level simulators.

TOTAL : 45 PERIODS

COURSE OUTCOMES

- Ability to analyze WSN with respect to various performance parameters in the protocol stack
- Ability to understand MAC algorithms and Network protocols used for specific WSN applications
- Design and develop a WSN for a given application

REFERENCE BOOKS

1. Feng Zhao and Leonidas J. Guibas, "Wireless Sensor Networks : An Information Processing Approach", Elsevier, 2004.
2. Holger Karl and Andreas Willig, "Protocols And Architectures for Wireless Sensor Networks", John Wiley, 2007.
3. Ivan Stojmenovic, "Handbook of Sensor Networks: Algorithms and Architectures", Wiley, 2005.
4. Kazem Sohraby, Daniel Minoli and Taieb Znati, "Wireless Sensor Networks :Technology, Protocols and Applications", John Wiley, 2007.
5. Bhaskar Krishnamachari, "Networking Wireless Sensors", Cambridge University Press, 2011.