ANNA UNIVERSITY, CHENNAI
AFFILIATED INSTITUTIONS
REGULATIONS – 2017
CHOICE BASED CREDIT SYSTEM
M.E. INSTRUMENTATION ENGINEERING

PROGRAM EDUCATIONAL OUTCOMES

PEO1: Graduates of this program will excel through the core competency skills inculcated with a strong foundation in Instrumentation and Process Control.

PEO2: Graduates of this program will have the capability to be successful in the chosen profession through commitment, effective communication, ethics and team work.

PEO3: Graduates of this program will exhibit self learning capability and demonstrate a pursuit in life-long learning through higher studies and research.

PEO4: Graduates of this program will show involvement and willingness in assuming responsibility in societal and environmental causes.

PROGRAM OUTCOMES

PO1: Acquire sound knowledge in Mathematics, Instrumentation, Control and advanced subjects in Instrumentation Engineering with ability to chose and provide appropriate solution to problems related to process control.

PO2: Analyze complex real world problems in Instrumentation Engineering and synthesize the information for conducting high level of research.

PO3: Think widely to solve problems related to Instrumentation Engineering and come up with a range of feasible optimal solutions considering health, safety, societal, and environmental factors.

PO4: Extract the new methodologies by carrying out the literature survey, proper design and conduction of experiments, interpret and analyze the data to arrive at meaningful research methodologies in Instrumentation and process control.

PO5: Learn and apply computing platform and Engineering software tools for solving problems related to Process Control, Automation, Measurement and Control etc.

PO6: Ability to form, understand group dynamics and work in inter-disciplinary groups in order to achieve the goal.

PO7: Communicate effectively the concepts and ideas with a wide range of engineering community and others, to understand and prepare reports, to make effective presentations.

PO8: Recognition of the need for and Engage in life-long learning to keep abreast with the technological developments.

PO9: Acquire the professional and research ethics, Understand the impact of research and responsibility in order to contribute to the society.

PO10: Understand the role of a leader, leadership principles to effective professional practice of Instrumentation Engineering.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
PEO-1	x	x	x	x	x		x	x		
PEO-2	x			x	x	x	x	x	x	x
PEO-3				x	x	x		x	x	
PEO-4	x	x	x						x	x

ANNA UNIVERSITY, CHENNAI
AFFILIATED INSTITUTIONS
REGULATIONS – 2017
CHOICE BASED CREDIT SYSTEM
M.E. INSTRUMENTATION ENGINEERING (FULL TIME)
CURRICULUM AND SYLLABUS I TO IV SEMESTERS

SEMESTER I

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	MA5155	Applied Mathematics for Electrical Engineers	FC	4	4	0	0	4
2.	IN5101	Process Control	PC	4	4	0	0	4
3.	IN5151	Transducers and Smart Instruments	PC	3	3	0	0	3
4.	IN5152	System Theory	PC	5	3	2	0	4
5.	ET5152	Design of Embedded Systems	PC	3	3	0	0	3
PRACTICALS								
6.	IN5161	Modeling and Simulation Laboratory	PC	4	0	0	4	2
			TOTAL	**23**	**17**	**2**	**4**	**20**

SEMESTER II

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	IN5201	Advanced Process Control	PC	4	4	0	0	4
2.	IN5202	Instrumentation System Design	PC	3	3	0	0	3
3.	IN5251	Applied Industrial Instrumentation	PC	3	3	0	0	3
4.		Professional Elective I	PE	3	3	0	0	3
5.		Professional Elective II	PE	3	3	0	0	3
6.		Professional Elective III	PE	3	3	0	0	3
PRACTICALS								
7.	IN5211	Process Control and Instrumentation Laboratory	PC	4	0	0	4	2
8.	IN5261	Automation Laboratory	PC	4	0	0	4	2
			TOTAL	**27**	**19**	**0**	**8**	**23**

SEMESTER III

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.		Professional Elective IV	PE	3	3	0	0	3
2.		Professional Elective V	PE	3	3	0	0	3
3.		Professional Elective VI	PE	3	3	0	0	3
PRACTICALS								
4.	IN5311	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.	IN5411	Project Work Phase II	EEC	24	0	0	24	12
			TOTAL	**24**	**0**	**0**	**24**	**12**

TOTAL NO. OF CREDITS : 70

FOUNDATION COURSES (FC)

S.No	Course Code	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	MA5155	Applied Mathematics for Electrical Engineers	FC	4	4	0	0	4

PROFESSIONAL CORE (PC)

S.No	Course Code	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	IN5101	Process Control	PC	4	4	0	0	4
2.	IN5151	Transducers and Smart Instruments	PC	3	3	0	0	3
3.	IN5152	System Theory	PC	5	3	2	0	4
4.	ET5152	Design of Embedded Systems	PC	3	3	0	0	3
5.	IN5161	Modeling and Simulation Laboratory	PC	4	0	0	4	2
6.	IN5201	Advanced Process Control	PC	4	4	0	0	4
7.	IN5202	Instrumentation System Design	PC	3	3	0	0	3
8.	IN5251	Applied Industrial Instrumentation	PC	3	3	0	0	3
9.	IN5211	Process Control and Instrumentation Laboratory	PC	4	0	0	4	2
10.	IN5261	Automation Laboratory	PC	4	0	0	4	2

PROFESSIONAL ELECTIVES (PE)*
SEMESTER II
ELECTIVE I, II, III

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	IN5071	Modeling and Simulation	PE	3	3	0	0	3
2.	ET5071	Advanced Digital Signal Processing	PE	3	3	0	0	3
3.	ET5092	Digital Image Processing	PE	3	3	0	0	3
4.	IN5001	Biomedical Instrumentation	PE	3	3	0	0	3
5.	IN5091	Soft Computing Techniques	PE	3	3	0	0	3
6.	IN5072	Industrial Data Networks	PE	3	3	0	0	3
7.	IN5002	Thermal Power Plant Instrumentation	PE	3	3	0	0	3

8.	IN5003	State and Parameter Estimation	PE	3	3	0	0	3
9.	IN5004	Industrial Standards	PE	3	3	0	0	3

SEMESTER III
ELECTIVE IV, V AND VI

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	IN5073	Robust Control	PE	3	3	0	0	3
2.	IN5074	Optimal Control	PE	3	3	0	0	3
3.	IN5075	System Identification and Adaptive Control	PE	3	3	0	0	3
4.	IN5076	Fault Tolerant Control	PE	3	3	0	0	3
5.	IN5077	Internet of Things and Applications	PE	3	3	0	0	3
6.	ET5091	MEMS Technology	PE	3	3	0	0	3
7.	IN5005	Instrumentation in Petrochemical Industries	PE	3	3	0	0	3
8.	IN5006	Safety Instrumented Systems	PE	3	3	0	0	3
9.	IN5078	Wireless Sensor Networks	PE	3	3	0	0	3
10.	IN5092	Digital Instrumentation	PE	3	3	0	0	3
11.	IN5079	Robotics and Control	PE	3	3	0	0	3

***Professional Electives are grouped according to elective number as was done previously.**

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S.No	Course Code	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	IN5311	Project Work Phase I	EEC	12	0	0	12	6
2.	IN5411	Project Work Phase II	EEC	24	0	0	24	12

MA5155 APPLIED MATHEMATICS FOR ELECTRICAL ENGINEERS

L	T	P	C
4	0	0	4

OBJECTIVES :

- The main objective of this course is to demonstrate various analytical skills in applied mathematics and extensive experience with the tactics of problem solving and logical thinking applicable for the students of electrical engineering. This course also will help the students to identify, formulate, abstract, and solve problems in electrical engineering using mathematical tools from a variety of mathematical areas, including matrix theory, calculus of variations, probability, linear programming and Fourier series.

UNIT I MATRIX THEORY 12

Cholesky decomposition - Generalized Eigenvectors - Canonical basis - QR Factorization - Least squares method - Singular value decomposition.

UNIT II CALCULUS OF VARIATIONS 12

Concept of variation and its properties – Euler's equation – Functional dependant on first and higher order derivatives – Functionals dependant on functions of several independent variables – Variational problems with moving boundaries – Isoperimetric problems - Direct methods : Ritz and Kantorovich methods.

UNIT III PROBABILITY AND RANDOM VARIABLES 12

Probability – Axioms of probability – Conditional probability – Baye's theorem - Random variables - Probability function – Moments – Moment generating functions and their properties – Binomial, Poisson, Geometric, Uniform, Exponential, Gamma and Normal distributions – Function of a random variable.

UNIT IV LINEAR PROGRAMMING 12

Formulation – Graphical solution – Simplex method – Big M method - Two phase method - Transportation and Assignment models.

UNIT V FOURIER SERIES 12

Fourier trigonometric series : Periodic function as power signals – Convergence of series – Even and odd function : Cosine and sine series – Non periodic function : Extension to other intervals - Power signals : Exponential Fourier series – Parseval's theorem and power spectrum – Eigenvalue problems and orthogonal functions – Regular Sturm - Liouville systems – Generalized Fourier series.

TOTAL : 60 PERIODS

OUTCOMES :

After completing this course, students should demonstrate competency in the following skills:

- Apply various methods in matrix theory to solve system of linear equations.
- Maximizing and minimizing the functional that occur in electrical engineering discipline.
- Computation of probability and moments, standard distributions of discrete and continuous random variables and functions of a random variable.

- Could develop a fundamental understanding of linear programming models, able to develop a linear programming model from problem description, apply the simplex method for solving linear programming problems.
- Fourier series analysis and its uses in representing the power signals.

REFERENCES :

1. Andrews L.C. and Phillips R.L., "Mathematical Techniques for Engineers and Scientists", Prentice Hall of India Pvt. Ltd., New Delhi, 2005.
2. Bronson, R. “Matrix Operation”, Schaum’s outline series, 2nd Edition, McGraw Hill, 2011.
3. Elsgolc, L. D. "Calculus of Variations", Dover Publications, New York, 2007.
4. Johnson, R.A., Miller, I and Freund J., "Miller and Freund’s Probability and Statistics for Engineers", Pearson Education, Asia, 8th Edition, 2015.
5. O’Neil, P.V., "Advanced Engineering Mathematics", Thomson Asia Pvt. Ltd., Singapore, 2003.
6. Taha, H.A., “Operations Research, An Introduction”**,** 9th Edition, Pearson education, New Delhi, 2016.

IN5101	PROCESS CONTROL	L	T	P	C
		4	0	0	4

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 & CONTROL ACTIONS 12

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 - 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

UNIT II PID CONTROLLER TUNING – SINGLE LOOP REGULATORY CONTROL 12

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.

UNIT III ENHANCEMENT TO SINGLE LOOP REGULATORY CONTROL & MODEL BASED CONTROL SCHEMES 12

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 12

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 12

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 : 60 PERIODS

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

TEXT 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, “Process Dynamics and Control”, John Wiley and Sons, 2010.
3. Jose A. Romagnoli and Ahmet Palazoglu , "Introduction to Process Control", CRC Press, Taylor and Francis Group, Second Edition, First Indian Reprint, 2010.
4. Coleman Brosilow and Babu Joseph, "Techniques of Model-based Control", Prentice Hall International Series, PTR, New Jersey, 2001.

IN5151	TRANSDUCERS AND SMART INSTRUMENTS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To give an overview of the working and characteristics of conventional transducers
- To provide a detailed knowledge on error and determination of uncertainties in measurement.
- To give a comprehensive knowledge on smart sensor design, development and interface details.
- To give exposure to manufacturing techniques and different types of Micro sensors and actuators
- To give an exposure of latest trends in sensor technologies including multisensor data

fusion.

UNIT I OVERVIEW OF CONVENTIONAL TRANSDUCERS AND THEIR 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 – limiting error and probable error - 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

UNIT III SMART SENSORS 9

Definition – Integrated smart sensors –sensing elements –design of Interface electronics - parasitic effects – sensor linearization - Dynamic range - Universal Sensor Interface - front end circuits - DAQ – Design – Digital conversion - Microcontrollers and digital signal processors for smart sensors – selection criteria - 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

OUTCOMES:

- Compare conventional transducers and select the suitable one for the given application
- Analyze and quantify the uncertainties in measurement data.
- Design and develop customized smart sensors for different applications
- 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.

TEXT BOOKS:

1. Ernest O Doebelin and Dhanesh N Manik, “Measurement Systems Application and Design”, 5th Edition, 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.

IN5152	SYSTEM THEORY	L	T	P	C
		3	2	0	4

OBJECTIVES:

- To understand the fundamentals of physical systems in terms of its linear and nonlinear models.
- To educate on representing systems in state variable form
- To educate on solving linear and non-linear state equations
- To exploit the properties of linear systems such as controllability and observability
- To educate on stability analysis of systems using Lyapunov's theory
- To educate on modal concepts and design of state and output feedback controllers and estimators

UNIT I STATE VARIABLE REPRESENTATION 9

Introduction-Concept of State-State equations for Dynamic Systems -Time invariance and linearity- Non uniqueness of state model- Physical Systems and State Assignment - free and forced responses- State Diagrams.

UNIT II SOLUTION OF STATE EQUATIONS 9

Existence and uniqueness of solutions to Continuous-time state equations - Solution of Nonlinear and Linear Time Varying State equations - State transition matrix and its properties – Evaluation of matrix exponential- System modes- Role of Eigen values and Eigen vectors.

UNIT III STABILITY ANALYSIS OF LINEAR SYSTEMS 9

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

UNIT IV STATE FEEDBACK CONTROL AND STATE ESTIMATOR 9

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

UNIT V LYAPUNOV STABILTY ANALYSIS 9

Introduction-Equilibrium Points- BIBO Stability-Stability of LTI Systems- Stability in the sense of Lyapunov - Equilibrium Stability of Nonlinear Continuous-Time Autonomous Systems-The Direct Method of Lyapunov and the Linear Continuous-Time Autonomous Systems-Finding Lyapunov Functions for Nonlinear Continuous-Time Autonomous Systems – Krasovskil's and Variable-Gradiant Method.

TOTAL : 45 + 30 = 75 PERIODS

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.

TEXT BOOKS:

1. M. Gopal, “Modern Control System Theory”, New Age International, 2005.
2. K. Ogatta, “Modern Control Engineering”, PHI, 2002.
3. John S. Bay, “Fundamentals of Linear State Space Systems”, McGraw-Hill, 1999.
4. D. Roy Choudhury, “Modern Control Systems”, New Age International, 2005.
5. John J. D’Azzo, C. H. Houpis and S. N. Sheldon, “Linear Control System Analysis and Design with MATLAB”, Taylor Francis, 2003.
6. Z. Bubnicki, ”Modern Control Theory”, Springer, 2005.
7. C.T. Chen, “Linear Systems Theory and Design’’ Oxford University Press, 3rd Edition, 1999.
8. M. Vidyasagar, “Nonlinear Systems Analysis’, 2nd edition, Prentice Hall, Englewood Cliffs, New Jersey.

ET5152	**DESIGN OF EMBEDDED SYSTEMS**	**L T P C**
		3 0 0 3

COURSE OBJECTIVES

- To provide a clear understanding on the basic concepts, Building Blocks of Embedded System
- To teach the fundamentals of Embedded processor Modeling , Bus Communication in processors, Input/output interfacing
- To introduce on processor scheduling algorithms , Basics of Real time operating system
- To discuss on aspects required in developing a new embedded processor, different Phases & Modeling of embedded system
- To involve Discussions/ Practice/Exercise onto revising & familiarizing the concepts acquired over the 5 Units of the subject for improved employability skills

UNIT I INTRODUCTION TO EMBEDDED SYSTEMS 9

Introduction to Embedded Systems –Structural units in Embedded processor, selection of processor & memory devices- DMA, Memory management methods- memory mapping, cache replacement concept, Timer and Counting devices, Watchdog Timer, Real Time Clock

UNIT II EMBEDDED NETWORKING AND INTERRUPTS SERVICE MECHANISM 9

Embedded Networking: Introduction, I/O Device Ports & Buses– Serial Bus communication protocols - RS232 standard – RS485 –USB – Inter Integrated Circuits (I^2C) – interrupt sources , Programmed-I/O busy-wait approach without interrupt service mechanism- ISR concept-– multiple interrupts – context and periods for context switching, interrupt latency and deadline -Introduction to Basic Concept Device Drivers.

UNIT III RTOS BASED EMBEDDED SYSTEM DESIGN 9

Introduction to basic concepts of RTOS- Task, process & threads, interrupt routines in RTOS, Multiprocessing and Multitasking, Preemptive and non-preemptive scheduling, Task communication-shared memory, message passing-, Interprocess Communication – synchronization between processes-semaphores, Mailbox, pipes, priority inversion, priority inheritance-comparison of commercial RTOS features - RTOS Lite, Full RTOS, VxWorks, µC/OS-II, RT Linux,

UNIT IV SOFTWARE DEVELOPMENT TOOLS **9**

Software Development environment-IDE, assembler, compiler, linker, simulator, debugger, Incircuit emulator, Target Hardware Debugging, need for Hardware-Software Partitioning and Co-Design. Overview of UML, Scope of UML modeling, Conceptual model of UML, Architectural, UML basic elements-Diagram- Modeling techniques - structural, Behavioral, Activity Diagrams.

UNIT V EMBEDDED SYSTEM APPLICATION DEVELOPMENT **9**

Objectives, different Phases & Modeling of the Embedded product Development Life Cycle (EDLC), Case studies on Smart card- Adaptive Cruise control in a Car -Mobile Phone software for key inputs.

Note: Class Room Discussions and Tutorials can include the following Guidelines for improved Teaching /Learning Process: Practice through any of Case studies through Exercise/Discussions on Design , Development of embedded Products like : Smart card -Adaptive Cruise control in a Car -Mobile Phone -Automated Robonoid

TOTAL: 45 PERIODS

OUTCOMES : After the completion of this course the student will be able to:

- An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- Describe the differences between the general computing system and the embedded system, also recognize the classification of embedded systems
- Design real time embedded systems using the concepts of RTOS.
- Foster ability to understand the role of embedded systems in industry

REFERENCES

1. Rajkamal, ‘Embedded system-Architecture, Programming, Design’, TMH,2011.
2. Peckol, “Embedded system Design”,JohnWiley&Sons,2010
3. Shibu.K.V, “Introduction to Embedded Systems”, TataMcgraw Hill,2009
4. Lyla B Das,” Embedded Systems-An Integrated Approach”,Pearson2013
5. Elicia White,”Making Embedded Systems”,O’Reilly Series,SPD,2011
6. Bruce Powel Douglass,”Real-Time UML Workshop for Embedded Systems,Elsevier,2011
7. Simon Monk, “Make: Action, Movement, Light and Sound with Arduino and Raspberry Pi”, O’Reilly Series ,SPD,2016.
8. Tammy Noergaard, ”Embedded System Architecture, A comprehensive Guide for Engineers and Programmers”, Elsevier, 2006
9. Jonathan W.Valvano,”Embedded Microcomputer Systems ,Real Time Interfacing”,Cengage Learning,3rd edition,2012
10. Michael Margolis,”Arduino Cookbook, O’Reilly Series ,SPD,2013.

IN5161 MODELING AND SIMULATION LABORATORY

L	T	P	C
0	0	4	2

OBJECTIVES:

- To get knowledge about software packages required for solving algebraic equations.
- To design different controllers.
- To simulate system application involving nonlinear models.

Use of standard routines in Matlab/Simulink and Scilab/Scicos packages:

1) Solving nonlinear single and simultaneous nonlinear algebraic equations;
2) Solving IVP Odes
3) To find the eigen values, eigen vectors of a given matrix. Solution of Ax=b
4) To set up simulation diagram of a simple feedback block diagram (First order plus time delay system with a proportional controller) and find out the ultimate controller gain and frequency of oscillation.
5) For the FOPTD system considered in problem (4), Calculate the PI and PID settings by Ziegler-Nichols continuous cycling method. Compare the servo and regulatory performances.
6) Given a transfer function model design PI controller by ZN method &IMC method. Calculate the gain margin, phase margin and Maximum sensitivity function for these two methods.
7) Given nonlinear model equations of a bioreactor, linearise the model equations to get the transfer function model. Design a PI controller. Simulate the performance of the controller on the nonlinear system.
8) Set up a block diagram simulation of a 2x2 transfer function matrix (each subsystem as a FOPTD model) with decentralized PI control system. Using the closed loop system, with different values of the detuning factor compare the closed loop servo responses.
9) Given the input (x_1 and x_2) and output (y) data of a system and the model equation $y = k_1 Cx_1 x_2^m$, get the model parameters by the nonlinear least square routine.

TOTAL : 60 PERIODS

OUTCOMES:

- Ability to design different controllers for industrial applications
- Ability to get familiarize with matlab/Simulink for solving mathematical equations
- Ability to analyze the performance of nonlinear systems.

TEXT BOOKS:

1. S. L. Campbell, J.P.Chancelier and R. Nikoukhah, “Modeling and Simulation in Scilab/Scicos”, Springer, 2006
2. D.Xue, Y.Chen & D.E.Atherton, “Linera Fedback Control, analysis and design with Matlab/Simulink”, Siam Pub, Phildelpia, 2007

IN5201 ADVANCED PROCESS CONTROL LT P C
4 0 0 4

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

UNIT I DEVELOPMENT OF EMPIRICAL MODELS FROM PROCESS DATA FOR CONTROL 12

linear, nonlinear regression fitting for first order, second order models without and with time delay, development of discrete time model and identification

UNIT II ITERATIVE AND OVER PARAMETERIZATION METHODS 12

Compound Operator Decomposition and Its Application to Hammerstein and Wiener Systems-Introduction-Decomposition-Decomposition of Block-oriented Nonlinear Systems-Identification of Hammerstein–Wiener Systems

UNIT III DIGITAL SAMPLING, FILTERING AND CONTROL 12

sampling & signal reconstruction, signal processing and data filtering, Z-transform analysis for digital control, Velocity and position algorithms for PID controllers. Direct synthesis method, Dead beat and Dahlin's algorithms.

UNIT IV MODEL PREDICTIVE CONTROL 12

Overview of MPC, prediction for SISO and MIMO models, MPC calculation, set point calculation, selecting the tuning parameters in MPC–Design examples for typical case studies.

UNIT V CONTROL OF TIME-VARYING AND NONLINEAR SYSTEMS 12

Models for Time-varying and Nonlinear systems – Input signal design for Identification –Realtime 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

TOTAL : 60 PERIODS

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

TEXT BOOKS:

1. Seborg, D.E., Edgar, T.F. and Mellichamp, D.A., "Process Dynamics & Control", 2nd Ed., Wiley Student Edition, Singapore, 2004.
2. Stephanopoulos, G., "Chemical Process Control", Prentice-Hall India, New Delhi, 1984.
3. Luyben, W.L. & Luyben, M.L., "Essential Process Control", McGraw Hill Internation Ed., Singapore, 1997
4. Fouad Giri and Er-Wei Bai, "Block-oriented Nonlinear System Identification", Springer, 2010

IN5202 INSTRUCTIONS SYSTEM DESIGN

	L	T	P	C
IN5202 INSTRUMENTATION SYSTEM DESIGN	3	0	0	3

OBJECTIVES:

- To impart knowledge on the design of signal conditioning circuits required for selected sensors.
- To develop the skills needed to design transmitters, Analog/ Digital PID controller, Data Loggers and Alarm Annunciator
- To make the students familiarize with the design orifice and control valve sizing.

UNIT I DESIGN OF SIGNAL CONDITIONING CIRCUITS 9

Design of V/I Converter and I/V Converter – Signal conditioning circuit for pH electrodes, Design of Air-purge Level Measurement – Signal conditioning circuit for 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 for two applications - Design of configurable sequential controller using PLDs

TOTAL : 45 PERIODS

OUTCOMES:

- Design signal conditioning circuits for temperature sensors, V/I and I/V converters
- Design temperature and level transmitters, and smart transmitters
- Design data logger, PID controller and alarm circuits
- Carry out orifice and control valve sizing for different service

TEXT BOOKS:

1. C. D. Johnson, "Process Control Instrumentation Technology", 8th Edition, Prentice Hall, 2014.
2. Control Valve Handbook, "Emerson Process Management", Fisher Controls International, 4th Edition 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", CRC Press, 4th Edition, Vol.2, 2008.
5. Thakore and Bhatt, "Introduction to Process Engineering and Design",TATA McGraw-Hill,2007.

IN5251 APPLIED INDUSTRIAL INSTRUMENTATION **LT P C**
3 0 0 3

OBJECTIVES:

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

- the measurement techniques for flow, level, pressure and temperature.
- the selection and installation of instruments for power plant and petrochemical industries.
- the need and function of important industrial analyzers.
- advanced instrumentation used for providing safety.
- terminologies related to safety instrumented system and Hazard analysis.

UNIT I REVIEW OF INDUSTRIAL INSTRUMENTATION 9

Overview of Measurement of Flow, level, Temperature and Pressure.

UNIT II MEASUREMENT IN THERMAL POWER PLANT AND PETROCHEMICAL INDUSTRY 9

Selection and Installation of instruments used for the Measurement of fuel flow, Air flow, Drum level, Steam pressure, Steam temperature – Feed water quality measurement. Flow, Level, Temperature and Pressure measurement in Distillation, Pyrolysis, catalytic cracking and reforming process.

UNIT III INDUSTRIAL ANALYSER 9

Flue gas Oxygen Analyzers-Gas chromatography-dissolved oxygen analyzers-CO,CO_2 and NO_2 monitors-dust monitors-coal Analyzer- Hydrocarbon analyzers-oil in or on water- sulphur in oil Analyzer.

UNIT IV INSTRUMENTATION FOR INDUSTRIAL SAFETY 9

Electrical and Intrinsic Safety - Explosion Suppression and Deluge systems –Conservation and emergency vents - Flame, fire and smoke detectors - Leak Detectors - Metal Detectors.

UNIT V 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.

TOTAL : 45 PERIODS

OUTCOMES:

- The student will gain knowledge on instrumentation for flow, level, pressure and temperature.
- would gain knowledge on measuring devices involved with power plant and petrochemical industries.
- Will be able to explain the principle behind the important industrial analyzers.
- Will get idea on measuring devices associated with critical industrial applications.
- Would gain knowledge on analysis of hazardous events and safety instrumented system.

TEXT BOOKS:

1. B.G.Liptak, “Instrumentation Engineers Handbook (Process Measurement & Analysis)”, Fourth Edition, Chilton Book Co, 2003.
2. K.Krishnaswamy and M.Ponnibala, “Power Plant Instrumentation”, PHI Learning Pvt Ltd, 2011.

3. John G Webster, “The Measurement, Instrumentation, and Sensors Handbook”, CRC and IEEE Press, 1999.
4. Håvard Devold, “Oil and Gas Production Handbook - An Introduction to Oil and Gas Production”,ABB ATPA oil and gas, 2006.
5. Paul Gruhn, P.E., CFSE and Harry Cheddie, P.E., “Safety Instrumented Systems:Design, Analysis, and Justification”, ISA, 2nd Edition, 2006.
6. Al.Sutko,Jerry.D.Faulk, “Industrial Instrumentation”, Delmar publishers, 1996

IN5211	PROCESS CONTROL AND INSTRUMENTATION LABORATORY	L	T	P	C
		0	0	4	2

OBJECTIVES:

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

- Process symbols, PFD and P&ID of any plant.
- Different tuning methods for tuning PID controller.
- The design of advanced control schemes like feed forward and cascade controllers
- Model based control schemes like MPC

1. Study of any Process Control Test Rig with P&ID, PFD and Instrumentation symbols.
2. Simulation of lumped parameter and Distributed parameter systems
3. Identification of linear dynamic model of a process using non- parametric methods.
4. Design and implementation PID Control scheme on the simulated process. By different tuning methods
5. PID Implementation issues: Auto/Manual transfer, Anti reset wind up, p_kick and D_kick elimination
6. Level and pressure control (with and without Interaction) in process control Test Rig.
7. Auto- Tuning of PID controller
8. Design and implementation of Multi-loop PID and Multivariable PID control schemes on the simulated model of two-tank systems.
9. Design and implementation of Feed forward and Cascade control schemes on the simulated model of CSTR process
10. Design and implementation of Self-tuning and Gain scheduled adaptive Control schemes on the simulated model of variable area tank process.
11. Study of MPC toolbox and Design of MPC for simulated CSTR process.
12. One experiment beyond Syllabus

TOTAL : 60 PERIODS

OUTCOMES:

- Understand the concept of process symbols, PFD and P&ID.
- Tune PID controllers by using different tuning methods.
- Design MPC, feed forward and cascade controllers for any industrial process.

IN5261	AUTOMATION LABORATORY	L	T	P	C
		0	0	4	2

OBJECTIVES:

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

- Interpretation of Piping & Instrumentation Diagrams
- Interfacing pilot plants with Industrial Type Distributed Control System
- Programming of Industrial Type Programmable Logic Controller (Ladder Logic and Function Block Programming)
- Design and implementation of advanced control schemes.

1. Interpretation of P & ID (ISA 5.1)
2. Control of a typical 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. Configure Function Blocks and develop Feedback and Cascade Control Strategies using Function Blocks in industrial type Distributed Control system.
7. On-line monitoring and control of a pilot plant using an industrial type distributed control system.
8. Simple exercises using the Instruction Set of Industrial Type Programmable Logic Controller.
9. Programmable logic controller exercises for Filling / Draining control operation
10. Programmable logic controller exercises for Reversal of dc motor direction
11. Control of level and flow measurement system using industrial type programmable logic controller.

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

TOTAL : 60 PERIODS

OUTCOMES:

- 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
- 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

IN5071	MODELING AND SIMULATION	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To Teach how to mathematically model engineering systems
- To educate on how to use computer tools to solve the resulting mathematical models.
- To understand the computer tool used is MATLAB and the focus will be on developing and solving models of problems encountered in aerospace engineering and mechanics.

UNIT I OVERVIEW OF MATHEMATICAL MODELING 9

Mathematical Model, classification of model equations, Development of mathematical model, Simulation, Nonlinear Differential Equations, Conservation of Mass/Energy/Momentum, Black Box Models

UNIT II MODEL DEVELOPMENTS FOR SIMPLE SYSTEMS 9

Settling velocity of spherical particle, Vaporization from a single droplet in quiescent air, Modeling of a surge tank, Modeling of the pH process, Modeling of a long chain polymerization reaction, PDE model for tubular reactor with axial dispersion.

UNIT III MODEL DEVELOPMENTS FOR COMPLEX SYSTEMS 9

Isothermal CSTR, Lineraisation of a nonlinear equation, Bioreactor Modeling, Magnetic levitation (unstable systems), Choletts model with input multiplicities, Model for predators and Prey populations, Non-Isothermal continuous stirred tank reactor.

UNIT IV NUMERICAL SOLUTIONS OF MODEL EQUATIONS 9

Newton – Raphson's method for a system of nonlinear algebraic equations; Runge-Kutta Methods of solving numerically IVP ODEs, Numerical solution of nonlinear BVP ODEs**,** Numerical solution of nonlinear PDE, Least square Curve Fitting ,Variable transformation to get a linear equation.

UNIT V SIMULATION USING STANDARD ROUTINES 9

MATLAB and SCILAB programs for solving nonlinear algebraic equations, nonlinear IVP ODEs, BVP ODEs, parameter estimation problems with examples

TOTAL : 45 PERIODS

OUTCOMES:

- An ability to apply knowledge of math, science, and engineering. This will be accomplished by applying these disciplines to various problems in Modeling.
- An ability to identify, formulates, and solves engineering problems. This will be accomplished by using MATLAB to simulate the solution to various problems in design.
- An ability to use the techniques and skills of modern engineering tools necessary for the engineering practice. This objective will be accomplished by using Matlab.

TEXT BOOKS:

1. Bequette, B.W., "Process Dynamics: Modeling, Analysis and Simulation", Prentice-Hall International, Singapore, 1998.

2. Jana, A.K, "Chemical Process Modeling and Computer simulation", Prentice-Hall-India, New Delhi, 2011,

3. Finlayson, B.A., "Introduction to Chemical Engineering Computing", Wiley Student Edition, Singapore, 2006.

4. M.Chidambaram, "Mathematical Modeling and Simulation for Engineers", Cambridge University Press, New Delhi -2017

ET5071 ADVANCED DIGITAL SIGNAL PROCESSING

L T P C
3 0 0 3

COURSE OBJECTIVES

- To expose the students to the fundamentals of digital signal processing in frequency domain& its application
- To teach the fundamentals of digital signal processing in time-frequency domain& its application
- To compare Architectures & features of Programmable DSprocessors & develop logical functions of DSProcessors
- To discuss on Application development with commercial family of DS Processors
- To involve Discussions/ Practice/Exercise onto revising & familiarizing the concepts acquired over the 5 Units of the subject for improved employability skills

UNIT I FUNDAMENTALS OF DSP 12

Frequency interpretation, sampling theorem, aliasing, discrete-time systems, constant-coefficient difference equation. Digital filters: FIR filter design – rectangular,Hamming,Hanning windowing technique. IIR filter design – Butterworth filter, bilinear transformation method, frequency transformation. Fundamentals of multirate processing – decimation and interpolation.

UNIT II TRANSFORMS AND PROPERTIES 9

Discrete Fourier transform (DFT): - properties, Fast Fourier transform (FFT), DIT-FFT, and DIF-FFT. Wavelet transforms:Introduction, wavelet coefficients – orthonormal wavelets and their relationship to filter banks, multi-resolution analysis, and Haar and Daubechies wavelet.

UNIT III ADAPTIVE FILTERS 9

Wiener filters – an introduction. Adaptive filters: Fundamentals of adaptive filters, FIR adaptive filter – steepest descent algorithm, LMS algorithm, NLMS, applications – channel equalization. Adaptive recursive filters – exponentially weighted RLS algorithm.

UNIT IV ARCHITECTURE OF COMMERCIAL DIGITAL SIGNAL PROCESSORS 9

Introduction to commercial digital signal processors, Categorization of DSP processor – Fixed point and floating point, Architecture and instruction set of the TI TMS 320 C54xx and TMS 320 C6xxx DSP processors, On-chip and On-board peripherals – memory (Cache, Flash, SDRAM), codec, multichannel buffered I/O serial ports (McBSPs), interrupts, direct memory access (DMA), timers and general purpose I/Os.

UNIT V INTERFACING I/O PERIPHERALS FOR DSP BASED APPLICATIONS 6

Introduction, External Bus Interfacing Signals, Memory Interface, I/O Interface, Programmed I/O, Interrupts, Design of Filter, FFT Algorithm, ,Application for Serial Interfacing, DSP based Power Meter, Position control , CODEC Interface .

TOTAL : 45 PERIODS

Note: Discussions / Exercise / practice on signal analysis, transforms, filter design concepts with simulation tools such as Matlab / Labview / CC studio will help the student understand signal processing concepts and DSP processors.
Overview of TMS320C54xx and TMS320C67xx /other DSP Starter Kits, Introduction to code composer studio (CCS), Board support library, Chip support library and Runtime support library, Generating basic signals, Digital filter design, Spectrum analysis, Adaptive filters, Speech and Audio processing applications.

OUTCOMES : After the completion of this course the student will be able to:

- Students will learn the essential advanced topics in DSP that are necessary for successful Postgraduate level research.
- Students will have the ability to solve various types of practical problems in DSP
- Comprehend the DFTs and FFTs, design and Analyze the digital filters, comprehend the Finite word length effects in Fixed point DSP Systems.
- The conceptual aspects of Signal processing Transforms are introduced.
- The comparison on commercial available DSProcessors helps to understand system design through processor interface.
- Improved Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in embedded systems design.

REFERENCES:

1. John. G. Proakis, Dimitris G. Manolakis, “Digital signal processing”, Pearson Edu, 2002
2. Sen M.Kuo,Woon-Seng S.Gan, “Digital Signal Processors- Pearson Edu, 2012
3. Ifeachor E. C., Jervis B. W ,”Digital Signal Processing: A practical approach, Pearson-Education, PHI/ 2002
4. Shaila D. Apte, “ Digital Signal Processing”, Second Edition, Wiley, 2016.
5. Robert J.Schilling,Sandra L.Harris,”Introd. To Digital Signal Processing with Matlab”,Cengage,2014.
6. Steven A. Tretter, “Communication System Design Using DSP Algorithms with Laboratory Experiments for the TMS320C6713™ DSK”, Springer, 2008.
7. RulphChassaing and Donald Reay, “Digital Signal Processing and Applications with the TMS320C6713 and TMS320C6416 DSK”, John Wiley & Sons, Inc., Hoboken, New Jersey, 2008.
8. K.P. Soman and K.L. Ramchandran,Insight into WAVELETS from theory to practice, Eastern Economy Edition, 2008
9. B Venkataramani and M Bhaskar **“**Digital Signal Processors**”**, TMH, 2nd, 2010
10. Vinay K.Ingle,John G.Proakis,”DSP-A Matlab Based Approach”,Cengage Learning,2010
11. Taan S.Elali,”Discrete Systems and Digital Signal Processing with Matlab”,CRC Press2009.
12. Monson H. Hayes, “Statistical Digital signal processing and modelling”, John Wiley & Sons, 2008.
13. Avatar Sing, S. Srinivasan, “Digital Signal Processing- Implementation using DSP Microprocessors with Examples from TMS320C54xx”, Thomson India,2004.

ET5092	**DIGITAL IMAGE PROCESSING**	**L T P C**
		3 0 0 3

COURSE OBJECTIVES:

The objectives of this course to impart knowledge in

- the fundamentals of image processing
- the techniques involved in image enhancement
- the low and high-level features for image analysis
- the fundamentals and significance of image compression
- the hardware for image processing applications

UNIT I FUNDAMENTALS OF IMAGE PROCESSING 9

Introduction to image processing systems, sampling and quantization, color fundamentals and models, image operations – arithmetic, geometric and morphological. Multi-resolution analysis – image pyramids

UNIT II IMAGE ENHANCEMENT 9

Spatial domain; Gray-level transformations – histogram processing – spatial filtering, smoothing and sharpening. Frequency domain: filtering in frequency domain – DFT, FFT, DCT – smoothing and sharpening filters – Homomorphic filtering. Image enhancement for remote sensing images and medical images.

UNIT III IMAGE SEGMENTATION AND FEATURE ANALYSIS 9

Detection of discontinuities – edge operators – edge linking and boundary detection, thresholding – feature analysis and extraction – region based segmentation – morphological watersheds – shape skeletonization, phase congruency. Number plate detection using segmentation algorithm.

UNIT IV IMAGE COMPRESSION 9

Image compression: fundamentals – models – elements of information theory – error free compression – lossy compression – compression standards. Applications of image compression techniques in video and image transmission.

UNIT V EMBEDDED IMAGE PROCESSING 9

Introduction to embedded image processing. ASIC vs FPGA - memory requirement, power consumption, parallelism. Design issues in VLSI implementation of Image processing algorithms - interfacing. Hardware implementation of image processing algorithms: Segmentation and compression

TOTAL:45 PERIODS

COURSE OUTCOMES:

At the end of the course students will comprehend

- Fundamentals of image processing and techniques involved in image enhancement, segmentation and compression and their real-time applications
- The implementation of image processing applications using software and hardware.

NOTE:Discussions / Exercise / practice on Image enhancement, segmentation and compression with simulation tools such as Matlab/ Raspberry pi (python programming) will help the student understand image processing concepts and hardware implementation using relevant processors

REFERENCES:

1. Rafael C. Gonzalez and Richard E. Woods, “Digital Image processing”, 2nd edition, Pearson education, 2003
2. Anil K. Jain, “Fundamentals of digital image processing”, Pearson education, 2003
3. Milan Sonka, ValclavHalavac and Roger Boyle, “Image processing, analysis and machine vision”, 2nd Edition, Thomson learning, 2001
4. Mark Nixon and Alberto Aguado,“Feature extraction & Image processing for computer vision”,3rd Edition, Academic press, 2012
5. Donald G. Bailey, “Design for Embedded Image processing on FPGAs” John Wiley and Sons, 2011.

IN5001 BIOMEDICAL INSTRUMENTATION

L	T	P	C
3	0	0	3

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.

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

OUTCOMES:

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

TEXT 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.

IN5091	SOFT COMPUTING TECHNIQUES	L	T	P	C
		3	0	0	3

OBJECTIVES:
- To expose the concepts of feed forward neural networks.
- To provide adequate knowledge about feed back neural networks.
- To teach about the concept of fuzziness involved in various systems.
- To expose the ideas about genetic algorithm
- To provide adequate knowledge about of FLC and NN toolbox

UNIT I INTRODUCTION AND ARTIFICIAL NEURAL NETWORKS 9

Introduction to intelligent systems- Soft computing techniques- Conventional Computing versus Swarm Computing - Classification of meta-heuristic techniques - Properties of Swarm intelligent Systems - Application domain - Discrete and continuous problems - Single objective and multi-objective problems -Neuron- Nerve structure and synapse- Artificial Neuron and its model- activation functions- Neural network architecture- single layer and multilayer feed forward networks- Mc Culloch Pitts neuron model- perceptron model- Adaline and Madaline- multilayer perception model- back propogation learning methods- effect of learning rule coefficient -back propagation algorithm- factors affecting back propagation training- applications.

UNIT II ARTIFICIAL NEURAL NETWORKS AND ASSOCIATIVE MEMORY 9

Counter propagation network- architecture- functioning & characteristics of counter Propagation network- Hopfield/ Recurrent network configuration - stability constraints associative memory and characteristics- limitations and applications- Hopfield v/s Boltzman machine- Adaptive Resonance Theory- Architecture- classifications- Implementation and training - Associative Memory.

UNIT III FUZZY LOGIC SYSTEM 9

Introduction to crisp sets and fuzzy sets- basic fuzzy set operation and approximate reasoning. Introduction to fuzzy logic modeling and control- Fuzzification inferencing and defuzzification-Fuzzy knowledge and rule bases-Fuzzy modeling and control schemes for nonlinear systems. Self organizing fuzzy logic control- Fuzzy logic control for nonlinear time delay system.

UNIT IV GENETIC ALGORITHM 9

Evolutionary programs – Genetic algorithms, genetic programming and evolutionary programming - Genetic Algorithm versus Conventional Optimization Techniques - Genetic representations and selection mechanisms; Genetic operators- different types of crossover and mutation operators - Optimization problems using GA-discrete and continuous - Single objective and multi-objective problems - Procedures in evolutionary programming.

UNIT V HYBRID CONTROL SCHEMES 9

Fuzzification and rule base using ANN–Neuro fuzzy systems-ANFIS – Fuzzy Neuron - Optimization of membership function and rule base using Genetic Algorithm –Introduction to Support Vector Machine- Evolutionary Programming-Particle Swarm Optimization - Case study – Familiarization of NN, FLC and ANFIS Tool Box.

TOTAL : 45 PERIODS

OUTCOMES:

- Will be able to know the basic ANN architectures, algorithms and their limitations.
- Also will be able to know the different operations on the fuzzy sets.
- Will be capable of developing ANN based models and control schemes for non-linear system.
- Will get expertise in the use of different ANN structures and online training algorithm.
- Will be knowledgeable to use Fuzzy logic for modeling and control of non-linear systems.
- Will be competent to use hybrid control schemes and P.S.O and support vector Regressive.

TEXT BOOKS:

1. Laurene V. Fausett, “Fundamentals of Neural Networks: Architectures, Algorithms And Applications”, Pearson Education.
2. Timothy J. Ross, “Fuzzy Logic with Engineering Applications” Wiley India, 2008.
3. Zimmermann H.J. "Fuzzy set theory and its Applications" Springer international edition, 2011.
4. David E.Goldberg, “Genetic Algorithms in Search, Optimization, and Machine Learning”, Pearson Education, 2009.
5. W.T.Miller, R.S.Sutton and P.J.Webrose, “Neural Networks for Control” MIT Press”, 1996.
6. T. Ross, “Fuzzy Logic with Engineering Applications”, Tata McGraw Hill, New Delhi, 1995.
7. Ethem Alpaydin, “Introduction to Machine Learning (Adaptive Computation and Machine Learning Series)”, MIT Press, 2004.
8. Corinna Cortes and V. Vapnik, " Support - Vector Networks, Machine Learning ” 1995.

IN5072	INDUSTRIAL DATA NETWORKS	L	T	P	C
		3	0	0	3

OBJECTIVES:

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

UNIT I DATA NETWORK FUNDAMENTALS 9

EIA 232 / EIA 485/ EIA 422 interface standard – 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 - Factors to be considered in selecting DCS – Case studies in DCS. HART- Introduction- Evolution of signal standard – HART communication protocol – Communication modes – HART Networks – HART commands – HART applications – MODBUS protocol structure – Function codes

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 - Devicenet- Industrial Ethernet - Introduction to OLE for process control - WSN technology - IOT- IIOT

TOTAL : 45 PERIODS

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.

TEXT BOOKS:

1. G.K.McMillan, "Process/Industrial Instrument and Controls Handbook", McGraw-Hill handbook, Fifth Edition, New York, 1999.
2. T.A. Hughes, "Programmable Logic Controllers: Resources for Measurements and Control Series", ISA Press, Fourth edition, 2005.
3. J.Berge, "Field Buses for Process Control: Engineering, Operation, and Maintenance", ISA Press, 2004.
4. S.Mackay, E.Wright, D.Reynders, and J.Park, "Practical Industrial Data Networks: Design, Installation and Troubleshooting", Newnes Publication, Elsevier, 2004.
5. Alasdair Gilchrist," Industry 4.0:The Industrial Internet of Things", A press, 2016.

IN5002 THERMAL POWER PLANT INSTRUMENTATION

L	T	P	C
3	0	0	3

OBJECTIVES:

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

- Processes involved with Thermal power plant
- Development of Mathematical model of different systems in Thermal power plant
- Conventional and advanced control schemes applied to important processes in Thermal Power Plant
- Measurement 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 – Process flow diagram of thermal power plant.

UNIT II BOILER MODELING 9

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

UNIT III BOILER CONTROL 9

Combustion control-Air/fuel ratio control-furnace draft control –Drum level control : single,two and three element control–Steam temperature Control– Control of super heater and reheater-Interlocks in Boiler Operation- Model predictive control of super heater.

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

Methods of calculation of boiler efficiency:-Direct and indirect methods - 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

OUTCOMES:

- The student will gain knowledge on 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.

TEXT BOOKS:

1. A.B.Gill, “Power Plant Performance”, Elsevier India, New Delhi , 2003.

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

IN5003	STATE AND PARAMETER ESTIMATION	L	T	P	C
		3	0	0	3

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

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.
-

TEXT 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. Karel J. Keesman, "System Identification an Introduction", Springer, 2011.
5. Tao Liu, Furong Gao, "Industrial Process Identification and control design, Step-test and relay-experiment-based methods", Springer- Verilog London Ltd, 2012.
6. Lennart Ljung, "System Identification: Theory for the user", Prentice Hall, Second edition, 1999.

IN5004	INDUSTRIAL STANDARDS	L	T	P	C
		3	0	0	3

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.

UNIT I STANDARDS ORGANIZATION 9

Standards: Introduction, International and National Standards organization, IEC, ISO, NIST, IEEE, ISA, API, BIS, DIN, JISC and ANSI − API: Process Measurement and Instrumentation (APIRP551), recommended practice for installation of the instruments – flow, level, temperature, pressure - Process Instrument and Control (API RP554): performance requirements and considerations for the selection, specification, installation and testing of process instrumentation and control systems.

UNIT II ISA STANDARDS 9

Documentation of Measurement and Control− Instruments and System (ISA 5): 5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7 − General Requirement for Electrical Equipment in Hazardous Location (ISA 12): 12.2, 12.4, 12.24, 12.29 Instrument Specification Forms (ISA20) − Measurement Transducers (ISA37)

UNIT III ISA STANDARDS - CONTROL VALVE AND ACTUATOR 9

Control Valve Standards (ISA75): 75.01, 75.04, 75.05, 75.7, 75.11, 75.13, 75.14, 75.23, 75.24, 75.26. − Valve Actuator (ISA 96): 96.01, 96.02, 96.03, 96.04.

UNIT IV ISA STANDARDS - FOSSIL AND NUCLEAR POWER PLANTS 9

Fossil Power Plant Standards (ISA 77): 77.14, 77.22, 77.30, 77.41, 77.42, 77.44, 77.60, 77.70 − Nuclear Power Plant Standards (ISA67): 67.01, 67.02, 67.03, 67.04, 67.06.

UNIT V BS , ISO, IEC, & ANSI 9

Measurement of Fluid Flow by means of Orifice Plates (ISO 5167/ BSI042) IEC 61131-3 – Programmable Controller – Programming Languages – Specification for Industrial Platinum Resistance Thermometer Sensors (BSI904) – International Thermocouple Reference Tables (BS4937) – Temperature Measurement Thermocouple (ANSIC96.1).

TOTAL : 45 PERIODS

OUTCOMES:

- Ability to understand the role of standards organization.
- Ability to interpret and follow different standards while carrying out installation of sensors, transmitters, Industrial automation systems, PLC programming, documentation, equipment selection in hazardous area and instrument specification forms.
- Ability to understand and follow different standards while performing control valve sizing, actuator sizing and orifice sizing etc.
- Ability to interpret and follow different standards while carrying out monitoring and control of fossil fuel power plants and nuclear power plants.

TEXT BOOKS:

1. API Recommended Practice 551, “Process Measurement Instrumentation”, American Petroleum Institute, Washington, D.C., 1st Edition, May 1993.
2. API Recommended Practice 554, “Process Instrumentation and Control – 3 parts”, American Petroleum Institute, Washington, D.C., 1st Edition, October 2008.
3. ISA standard 5, “Documentation of Measurement and Control Instruments and Systems”, ISA, North Carolina, USA.
4. ISA standard 12, “Electrical Equipment for Hazardous Locations”, ISA, North Carolina, USA.
5. ISA standard 20, “Instrument Specification Forms”, ISA, North Carolina, USA.
6. ISA standard 37, “Measurement Transducers”, ISA, North Carolina, USA.
7. ISA standard 75, “Control Valve Standards”, ISA, North Carolina, USA.
8. ISA standard 96, “Valve Actuator”, ISA, North Carolina, USA.
9. ISA standard 77, “Fossil Power Plant Standards”, ISA, North Carolina, USA.
10. ISA standard 67, “Nuclear Power Plant Standards”, ISA, North Carolina, USA.

BS EN 60584-1, “Thermocouples - EMF specifications and tolerances”, British Standard, 2013.

IN5073 **ROBUST CONTROL**

L	T	P	C
3	0	0	3

OBJECTIVES:

- To introduce norms, random spaces and robustness measures.
- To educate the students on H2 optimal control and estimation techniques.
- To educate the students on H-infinity optimal control techniques.
- To educate the students on the LMI approach of H-infinity control.
- To educate the students 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 H2 optimal controllers – H2 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 – H-infinity 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 distillation column.

TOTAL : 45 PERIODS

OUTCOMES:

- 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

TEXT BOOKS:

1. Sinha A, “Linear Systems: Optimal and Robust Control”, CRC Press, 2007.
2. Da-Wei G, Petkov PH & Konstantinov MM “Robust Control Design with MATLAB”, New Age International, 2006.
3. Cheng D, Sun Y, Shen T & Ohmori H, “Advanced Robust And Adaptive Control Theory And Applications”, New Age International, 2010.
4. Green M & Limebeer DJN, “Linear Robust Control, Dover Publications Inc., 2012.
   Xue D, Chen YQ & Atherton, DP, “Linear Feedback Control: Analysis and Design with MATLAB”, Society for Industrial and Applied Mathematics (SIAM), 2007.

IN5074	OPTIMAL CONTROL	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To highlight the significance of optimal control in process industries and the different methods of optimization
- To introduce the concept of variational approach for the design of optimal control system
- To formulate linear quadratic optimal control strategy with specified degree of stability
- To impart knowledge about discrete time linear state regulator system and discrete time linear quadratic tracking system
- To illustrate the application of dynamic programming and HJB equation for the design of constrained and time optimal control systems

UNIT I INTRODUCTION TO OPTIMAL CONTROL 9

Statement of optimal Control problem - problem formulation and forms of optimal control - performance measures - various methods of optimization - Linear programming - nonlinear programming.

UNIT II CALCULUS OF VARIATIONS 9

Basic concepts – variational problem - Extreme functions with conditions - variational approach to optimal control systems.

UNIT III LINEAR QUADRATIC OPTIMAL CONTROL SYSTEM 9

Problem formulation - finite time LQR - infinite time LQR - Linear Quadratic tracking system – LQR with a specified degree of stability.

UNIT IV DISCRETE TIME OPTIMAL CONTROL SYSTEM 9

Variational calculus for DT system – DT optimal control system - DT linear state regulator system -- DT linear quadratic tracking system .

UNIT V PONTRYAGIN MINIMUM PRINCIPLE 9

Pontryagin minimum principle - Dynamic programming – Hamilton - Jacobi - Bellman equation - LQR system using HJB equation – Time optimal control – fuel optimal control system - optimal control system with constraints

TOTAL : 45 PERIODS

OUTCOMES:

After completing the course ,the student will be able to

- Formulate the optimization problem based on the requirements and evaluate the performance of optimal controller
- Apply the variational approach for optimal control systems with conditions
- Differentiate finite time LQR and infinite time LQR and design linear quadratic tracking system
- Analyze discrete time optimal control systems used in different applications
- Design constrained optimal control system and time optimal control system

TEXT BOOKS:

1. Naidu D.S, “Optimal Control System”, CRC Press, 2003
2. Kirk D.E, “Optimal Control Theory”, Dover publication, 2004
3. Lewis F.L. Draguna Vrabia, Syrmos V.L, “Optimal control”, John Wiley & sons, 2012.

IN5075	SYSTEM IDENTIFICATION AND ADAPTIVE CONTROL	L	T	P	C
		3	0	0	3

OBJECTIVES:

To give an overview on the different data driven identification methods

- To make the student understand the principles of relay based identification
- To enable the student to select a suitable model for identification
- To elaborate the concept of estimating the parameters of the selected
- models using parameter estimation algorithm
- To provide the background on the practical aspects of conducting experiments for real time system identification

UNIT I INTRODUCTION 9

System Identification - motivation and overview - Non-parametric methods: Impulse response, step response and Frequency response methods, correlation and spectral analysis methods.

UNIT II PARAMETER ESTIMATION METHODS 9

Parametric model structures-ARX, ARMAX, OE, BJ models -Linear regression -Least square estimates, statistical properties of LS Estimates. maximum likelihood estimation, Prediction error methods, Instrumental variable methods, Recursive Least squares method
-Exercises using system identification toolbox.

UNIT III RELAY FEEDBACK IDENTIFICATION 9

A generalized relay feedback identification method – model; structure selection - relay feedback identification of stable processes: FOPDT and SOPDT model. Illustrative examples

UNIT IV CLOSED-LOOP IDENTIFICATION 9

Identification of systems operating in closed loop: Identifiability considerations – direct identification – indirect identification -Subspace Identification methods : classical and innovation forms, Joint input–output identification

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 –Model validation and Model structure determination-case studies : identification of simple FOPDT and SOPDT systems.

TOTAL : 45 PERIODS

OUTCOMES:

- Ability to develop various models 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

TEXT BOOKS:

1. Karel J. Keesman, “System Identification an Introduction ”,Springer, 2011.
2. Lennart Ljung, “System Identification: Theory for the user”, Prentice Hall, Second edition, 1999.
3. Tao Liu, Furong Gao, “Industrial Process Identification and control design, Step-test and relay-experiment-based methods”, Springer-Verilog London Ltd, 2012.
4. T. S. Soderstrom, Petre G. Stoica, “System Identification”, Prentice Hall, 1989 .

IN5076	FAULT TOLERANT CONTROL	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To give an overview of different Fault Detection and Diagnosis methods
- 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.

UNIT I INTRODUCTION TO MODEL-BASED FAULT DIAGNOSIS 9

Introduction to Fault tolerant control - Types of faults and different tasks of Fault Diagnosis and Implementation -Mathematical representation of Faults and Disturbances: Additive and Multiplicative types – Residual Generation: Detection, Isolation, Computational and stability properties

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 - 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 ACTUATOR AND SENSOR FAULT-TOLERANT CONTROL DESIGN 9

Introduction - Plant Models - Nonlinear Model - Linear Model. Sensor Faults - Model-based Fault Diagnosis Actuator/Sensor Fault Representation -Actuator and Sensor Faults Estimation. Fault Estimation Based on -Unknown Input Observer - Decoupled Filter - Singular Value Decomposition .Sensor Fault-tolerant Control Design - Fault-tolerant Control Architecture -General Fault-tolerant Control Scheme.

UNIT V CASE STUDIES 9

Fault tolerant Control of Three-tank System –Diagnosis and Fault-tolerant control of Chemical process – Different types of faults in Control valves – Automatic detection, Application to a Winding Machine - Sensor Fault-tolerant Control Method for Active Suspension System.

TOTAL : 45 PERIODS

OUTCOMES:

- 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

TEXT BOOKS:

1. Hassan Noura, Didier Theilliol, Jean-Christophe Ponsart, Abbas Chamseddine, “Fault-Tolerant Control Systems: Design and Practical Applications”, Springer Publication, 2009
2. Janos J. Gertler, “Fault Detection and Diagnosis in Engineering systems” Marcel Dekker, 2nd Edition, 1998
3. Rolf Isermann, “Fault-Diagnosis Systems an Introduction from Fault Detection to Fault Tolerance”, Springer Verlag, 2006.
4. Ali Ahammad Shoukat Choudhury, Sirish L. Shah, Nina F. Thornhill, “Diagnosis of Process Nonlinearities and Valve Stiction: Data Driven Approaches”, Springer, 2008
5. Mogens Blanke, “Diagnosis and Fault-Tolerant Control”, Springer, 2003.

IN5077	INTERNET OF THINGS AND APPLICATIONS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To give an overview of the Interconnection and Integration of the Physical World with Cyber Space.
- To provide an insight into Design and Development of IOT application.

UNIT I INTERNET PRINCIPLES 9

Definition and Characteristics - IoT enabling technologies – Levels of deployment – Domain specific IoTs - SDN and NFV for IoT – ISO/OSI model – MAC address and IP address - Overview of TCP/IP and UDP -Basics of DNS - Classes of IP addresses - Static and dynamic addressing –Salient features of IPV4 – Specifications of IPV6 and 6LoPAN.

UNIT II PHYSICAL AND LOGICAL DESIGN METHODOLOGIES 9

Requirements and Specifications – Device and Component Integration ––Physical design using prototyping boards - Sensors and actuators, choice of processor, interfacing and networking - Logical Design – Open source platforms - Techniques for writing embedded code - Case studies and examples using Python programming and Arduino/Raspberry Pi prototyping boards – IoT application development using Wireless Sensor Networks - Single Node Architecture - Hardware Components, Energy Consumption of Sensor Nodes

UNIT III PROTOCOLS AND CLOUDS FOR IOT 9

Application layer protocols for IoT – MQTT and –Introduction to cloud storage models and communication APIs – Web application framework – Designing a web API – Web services - IoT device management

UNIT IV INDUSTRIAL IOT AND SECURITY 9

Introduction to the Industrial Internet - Networked Control Systems – Network delay modeling - Architecture and design methodologies for developing IoT application for Networked Control Systems – Example using SCADA system - Software Design Concepts - Middleware IIOT platforms- securing the Industrial Internet- Introduction of Industry 4.0.

UNIT V PROCESS DATA ANALYTICS 9

Process analytics - Dimensions for Characterizing process- process Implementation technology Tools and Use Cases- open source and commercial tools for Process analytics- Big data Analytics for process data - Analyzing Big process data problem – Crowdsourcing and Social BPM - Process data management in the cloud.

TOTAL : 45 PERIODS

OUTCOMES:

- Gain knowledge about the principles of Internet
- Ability to realize an IoT application using physical devices, operating systems and programming tools
- Realize the need for security and Cloud-based computing & storage for IoT.
- Ability to understand the concept of process data analytics

TEXT BOOKS:

1. ArshdeepBahga and Vijay Madisetti, “Internet of Things A Hands-on Approach”, Universities Press (India), 2015.
2. Alasdair Gilchrist," Industry 4.0: The Industrial Internet of Things”, A press, 2016.
3. Adrian McEwen and Hakim Cassimally, “Designing the Internet of Things”, John Wiley & Sons, 2014.
4. Francis Dacosta, “Rethinking the Internet of Things”, A press Open, 2013.
5. Beheshti**,** S.-M.-R., Benatallah**,** B., Sakr**,** S., Grigori, D., Motahari-Nezhad**,** H.R., Barukh**,** M.C., Gater, A., Ryu, S.H."Process AnalyticsConcepts and Techniques for Querying and Analyzing Process Data" Springer International Publishing Switzerland,2016.

ET5091 MEMS TECHNOLOGY L T P C
3 0 0 3

COURSE OBJECTIVES

- To teach the students properties of materials ,microstructure and fabrication methods.
- To teach the design and modeling of Electrostatic sensors and actuators.
- To teach the characterizing thermal sensors and actuators through design and modeling
- To teach the fundamentals of piezoelectric sensors and actuators through exposure to different MEMS and NEMS devices
- To involve Discussions/ Practice/Exercise onto revising & familiarizing the concepts acquired over the 5 Units of the subject for improved employability skills

UNIT I MICRO-FABRICATION, MATERIALS AND ELECTRO-MECHANICAL CONCEPTS 9

Overview of micro fabrication – Silicon and other material based fabrication processes – Concepts: Conductivity of semiconductors-Crystal planes and orientation-stress and strain-flexural beam bending analysis-torsional deflections-Intrinsic stress- resonant frequency and quality factor.

UNIT II ELECTROSTATIC SENSORS AND ACTUATION 9

Principle, material, design and fabrication of parallel plate capacitors as electrostatic sensors and actuators-Applications

UNIT III THERMAL SENSING AND ACTUATION 9

Principle, material, design and fabrication of thermal couples, thermal bimorph sensors, thermal resistor sensors-Applications.

UNIT IV PIEZOELECTRIC SENSING AND ACTUATION 9

Piezoelectric effect-cantilever piezoelectric actuator model-properties of piezoelectric materials-Applications.

UNIT V CASE STUDIES 9

Piezoresistive sensors, Magnetic actuation, Micro fluidics applications, Medical applications, Optical MEMS.-NEMS Devices

Note: Class room discussions and tutorials can include the following guidelines for improved teaching /learning process: Discussions/Exercise/Practice on Workbench: on the basics /device model design aspects of thermal/peizo/resistive sensors etc.

TOTAL : 45 PERIODS

OUTCOMES : After the completion of this course the student will be able to:

- Understand basics of microfabrication, develop models and simulate electrostatic and electromagnetic sensors and actuators
- Understand material properties important for MEMS system performance, analyze dynamics of resonant micromechanical structures
- The learning process delivers insight onto design of micro sensors, embedded sensors & actuators in power aware systems like grid.
- Understand the design process and validation for MEMS devices and systems, and learn the state of the art in optical microsytems
- Improved Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in embedded systems design.

REFERENCES

1. Chang Liu, “Foundations of MEMS”, Pearson International Edition, 2006.
2. Marc Madou , “Fundamentals of microfabrication”,CRC Press, 1997.
3. Boston , “Micromachined Transducers Sourcebook”,WCB McGraw Hill, 1998.
4. M.H.Bao “Micromechanical transducers :Pressure sensors, accelerometers and gyroscopes”, Elsevier, Newyork, 2000.

IN5005	INSTRUMENTATION IN PETROCHEMICAL INDUSTRIES	L	T	P	C
		3	0	0	3

OBJECTIVES:

To enable students to

- acquire knowledge about the different methods of crude oil exploration, recovery and processing
- learn about the important Unit operations involved with refinery and petrochemical

industries

- Understand the production routes of important petrochemicals.
- Familiarize the control loops for important petrochemicals production processes.
- Know about the classification of Hazardous zones, safety measures and standards.

UNIT I OIL EXTRACTION AND REFINING 9

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

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 DERIVATIVES OF PETROLEUM 9

Chemicals from methane, acetylene, ethylene and propylene - production routes of important petrochemicals: - carbon black, polyethylene, polypropylene, ethylene dioxide, methanol, xylene, benzene, toluene, styrene, glycerin-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 loops for VCM and PVC production processes.

UNIT V SAFETY AND STANDARDS APPLIED TO PETROCHEMICAL INDUSTRIES 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 - Lower and Upper explosion limit- Standards:-IEC 61508, API RP 14C, API RP554.

TOTAL : 45 PERIODS

OUTCOMES:

- Gain knowledge on the methodologies applied for exploration, recover processing of petroleum.
- Be familiar with different unit operations involved in Petroleum industry.
- Understand the production routes for important petrochemicals. Be able to understand the control loops involved with important processes like FCCU, Catalytic Reformer, and Alkylation.
- Be able to classify the hazardous zones and gain knowledge on standards applied to safety in petrochemical industries.

TEXT BOOKS:

1. Jens G. Balchen, Kenneth I. Mummé, “Process Control: Structures and Applications”, Von Nostrand Reinhold Company, New York, 1995. ABB ATPA Oil and Gas, 2006.
2. Håvard Devold, “Oil and Gas Production Handbook-An Introduction to Oil and Gas Production”
3. Béla G. Lipták, “Instrumentation in Process Industries”, Chilton Book Company, 2005.
4. Austen Lawrence Waddams, “Chemical from Petroleum”, Butter and Janner Ltd., 1968.
5. Ram Prasad, “Petroleum Refining Technology”, Khanna Publishers, New Delhi, 2000.

IN5006	SAFETY INSTRUMENTED SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES:

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

- standards applied to process control and instrumentation.
- function of safety life cycle and hazard analysis.
- the role of prevention and mitigation layers and their design.
- various SIL determination methods
- the selection of methodology for the designed safety instrumented system

UNIT I 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 II INTRODUCTIN TO SAFETY INSTRUMENTATION 9

Introduction to Safety Instrumented Systems – Hazards and Risk – Process Hazards Analysis(PHA) – Safety Life Cycle-Allocation of safety functions to protective layers-SIS design and engineering.

UNIT III PROTECTION LAYERS 9

Prevention layers:-process plant design-process control system-alarm systems-physical protection.

Mitigation layers:-containment system-scrubbers and flares-Fire and gas systems-Evacuation procedure.

UNIT IV SAFETY INTEGRITY LEVEL 9

Safety integrity levels- SIL determination methods-ALARP-Risk matrix-Risk graph-LOPA-examples for design of SIL

UNIT V SELECTION OF TECHNOLOGY 9

Relay systems-soli-state systems-microprocessor based systems-PLC based systems-safety PLCs-safety system complexity-communication with other systems

TOTAL : 45 PERIODS

OUTCOMES:

- The student will gain knowledge on different industrial standards.
- The student would gain knowledge on safety life cycle and function of protective layers.
- Will be able to understand the function of prevention and mitigation layers.
- Will be in a position to select the SIL for the given application.
- able to select the needed technology for the proposed safety instrumented system.

TEXT BOOKS:

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

3. 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.

IN5078	WIRELESS SENSOR NETWORKS	L	T	P	C
		3	0	0	3

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 – Introduction to LRWPAN – Design procedure for WSN development.

UNIT II PHYSICAL INTRODUCTION LAYER 9

Wireless 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 – MAC standards for WSN: IEEE 802.15.4 STD, ISA 100, low duty cycle protocols and Sleep-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**,** Wireless HART, PROFIBUS and MODBUS protocols.

UNIT V WSN DESIGN METHODOLOGY 9

Network Simulators and Programming tools for WSN – Programming Challenges – Security Challenges – Implementation Issues – case study on networked control system.

TOTAL : 45 PERIODS

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

TEXT BOOKS:

1. Ivan Stojmenovic, "Handbook of Sensor Networks: Algorithms and Architectures", Wiley, 2005.
2. Kazem Sohraby, Daniel Minoli and Taieb Znati, "Wireless Sensor Networks Technology, Protocols and Applications", John Wiley, 2007.
3. Bhaskar Krishnamachari,"Networking Wireless Sensors",Cambridge University Press, 2011.

IN5092	DIGITAL INSTRUMENTATION	LT P C 3 0 0 3

COURSE OBJECTIVES

- To discuss to the students on the fundamentals building blocks of a digital instrument
- To teach the digital data communication techniques
- To study on bus communication standards and working principles
- To teach Graphical programming using GUI for instrument building
- To involve Discussions/ Practice/Exercise onto revising & familiarizing the concepts acquired over the 5 Units of the subject for improved employability skills

UNIT I DATA ACQUISITION SYSTEMS 10

Overview of A/D converter, types and characteristics – Sampling, Errors. Objective – Building blocks of Automation systems -Calibration, Resolution, Data acquisition interface requirements.– Counters – Modes of operation- Frequency, Period, Time interval measurements, Prescaler, Heterodyne converter for frequency measurement, Single and Multi channel Data Acquisition systems-Digital storage Oscilloscope-digital display interface.

UNIT II INSTRUMENT COMMUNICATION 10

Introduction, Modem standards, Data transmission systems- Time Division Multiplexing (TDM) – Digital Modulation Basic requirements of Instrument Bus Communications standards, interrupt and data handshaking , serial bus- basics, Message transfer, - RS-232, USB, RS-422, Ethernet Bus- CAN standards interfaces .General considerations -advantages and disadvantages- Instrumentation network design ,advantages and limitations ,general considerations, architecture, model, and system configuration of : HART network, Mod Bus, Fieldbus

UNIT III VIRTUAL INSTRUMENTATION BASICS 12

Block diagram ,role,and Architecture for VI–– tool bar,Graphical system design &programming usingGUI – Virtual Instrumentation for test, control design-modular programming-conceptual and prog approaches for creation of panels,icons-Loops-Arrays-clusters-plotting data-structures-strings and File I/O- Instrument Drivers

UNIT IV CONFIGURING PROGRAMMABLE INSTRUMENTATION 7

Microprocessor based system design –Peripheral Interfaces systems and instrument communication standards –Data acquisition with processor and with VI – Virtual Instrumentation Software and hardware simulation of I/O communication blocks-peripheral interface – ADC/DAC – Digital I/O – Counter , Timer-servo motor control-PID control.

UNIT V CASE STUDIES 6

Processor based DAS, Data loggers, VI based process measurements like temperature, pressure and level development system- DSO interface -digital controller for colour video display.

Note: Class room discussions and tutorials can include the following guidelines for improved teaching /learning process :Discussions/Exercise/Practice on Workbench for Digital Control of Relays/Solenoids, Digital I/O – Counter , Timer-servo motor control-PID control.
/ LCD graphics Interface/storage interface,

TOTAL : 45 PERIODS

OUTCOMES : After the completion of this course the student will be able to:

- Use digital integrated circuit logic family chips.
- Perform computational and measurement activities using digital techniques, build sequential and combinational logic circuits.
- Analyse working of A/D and D/A converters, use display devices for digital circuits, use digital meters for measurements.
- Graduates will understand the fundamental principles of electrical and electronics circuits and instrumentation, enabling them to understand current technology and to adapt to new devices and technologies.
- Improved Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in embedded systems design.

REFERENCES:

1. Mathivanan, "PC based Instrumentation Concepts and practice", Prentice-Hall India, 2009
2. Jovitha Jerome,"Virtual Instrumentation using Labview"PHI,2010.
3. Gregory J. Pottie / William J. Kaiser, Principles Of Embedded Networked Systems Design, CAMBRIDGE UNIVERSITY PRESS (CUP),2016
4. Jonathan W Valvano, "Embedded Microcomputer systems", Brooks/Cole, Thomson, 2010.
5. Cory L.Clark,"Labview Digital Signal Processing & Digital Communication,TMcH,2005
6. Lisa K. wells & Jeffrey Travis, Lab VIEW for everyone, Prentice Hall, New Jersey,1997.
7. H S Kalsi, "Electronic Instrumentation" Second Edition, Tata McGraw-Hill,2006.
8. K.Padmanabhan, S.Ananthi A Treatise on Instrumentation Engineering ,I K Publish,2011
9. Gary Johnson, LabVIEW Graphical Programming, Second edition, McG Hill,Newyork, 1997.

IN5079 ROBOTICS AND CONTROL L T P C
3 0 0 3

COURSE OBJECTIVES

- To introduce robot terminologies and robotic sensors To educate direct and inverse kinematic relations
- To educate on formulation of manipulator Jacobians and introduce path planning

techniques
- To educate on robot dynamics
- To introduce robot control techniques

UNIT I INTRODUCTION AND TERMINOLOGIES 9

Definition-Classification-History- Robots components-Degrees of freedom-Robot joints-coordinates-Reference frames-workspace-Robot languages-actuators-sensors-Position, velocity and acceleration sensors-Torque sensors-tactile and touch sensors-proximity and range sensors- vision system-social issues.

UNIT II KINEMATICS 9

Mechanism-matrix representation-homogenous transformation-DH representation-Inverse kinematics solution and programming-degeneracy and dexterity

UNIT III DIFFERENTIAL MOTION AND PATH PLANNING 9

Jacobian-differential motion of frames-Interpretation-calculation of Jacobian-Inverse Jacobian- Robot Path planning

UNIT IV DYNAMIC MODELLING 9

Lagrangian mechanics- Two-DOF manipulator- Lagrange-Euler formulation – Newton- Euler formulation – Inverse dynamics

UNIT V ROBOT CONTROL SYSTEM 9

- Linear control schemes- joint actuators- decentralized PID control- computed torque control – force control- hybrid position force control- Impedance/ Torque control

TOTAL : 45 PERIODS

COURSE OUTCOMES:

- Ability to understand the components and basic terminology of Robotics
- Ability to model the motion of Robots and analyze the workspace and trajectory panning of robots
- Ability to develop application based Robots
- Abiilty to formulate models for the control of mobile robots in various industrial applications

REFERENCES

1. R.K. Mittal and I J Nagrath, " Robotics and Control", Tata MacGraw Hill, Fourth edition.
2. Saeed B. Niku ,"Introduction to Robotics ", Pearson Education, 2002.
3. Fu, Gonzalez and Lee Mcgrahill ,"Robotics ", international edition.
4. R.D. Klafter, TA Chmielewski and Michael Negin, "Robotic Engineering, An Integrated approach",Prentice Hall of India, 2003.