DEPARTMENT OF INSTRUMENTATION ENGINEERING

ANNA UNIVERSITY, CHENNAI

VISION OF THE DEPARTMENT

The Department of Instrumentation Engineering perseveres in becoming a Centre for Excellence inElectronics, Instrumentation, Process Control & Information Technology for Higher level learning, Research & Consultancy, and aims at imparting high quality education to students and professionals leading them towards global competence to become a preferred partner of the industry and community for providing Engineering solutions.

MISSION OF THE DEPARTMENT

- Provide the students with strong foundation in Electronics, Instrumentation and ControlEngineering.
- Enhance the core competency of the students to cater to the needs of the industries andresearch organizations.
- Update the curriculum periodically and to upgrade the laboratories with state-of-art equipment.
- Encourage faculty members to keep abreast of current trends through continuing educationalprograms.
- Carry out interdisciplinary research and consultancy in the cutting-edge technology.

ANNA UNIVERSITY, CHENNAI
UNIVERSITY DEPARTMENTS
M.E. INSTRUMENTATION ENGINEERING (SPECIALIZATION IN INDUSTRIAL AUTOMATION)
REGULATIONS 2023
CHOICE BASED CREDIT SYSTEM
CURRICULUM AND SYLLABUS I TO IV SEMESTERS

1. PROGRAMME EDUCATIONAL OBJECTIVES(PEOs): (3 or 5)

I	Excel in their preferred profession in government and private sectors.
II	Involve in life-long learning and work as faculty members in reputed educational institutions, imparting knowledge and skills in the field of instrumentation engineering to the younger generations thereby producing talented engineers.
III	Carry out ground-breaking research in emerging areas in the field of instrumentation engineering, and thereby solving various technical and societal problems at national and global levels.
IV	Promote new ideas, innovation solutions and alternative methods in their work places contributing to the development of entrepreneurship. Exhibit leadership and inter-personal skills.
V	Adhere to professional ethics and exhibit leadership and inter-personal skills in their workplace.

2. PROGRAMME OUTCOMES(POs):

PO	Programme Outcomes
1	An ability to independently carry out research/investigation and development work to solve practical problems.
2	An ability to write and present a substantial technical report/document.
3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.
4	Select and apply relevant techniques, Engineering and IT tools for Engineering activities like modeling and control of systems/processes and also being conscious of the limitations.
5	Demonstrate the knowledge and understanding of Engineering and Management principles and to apply these to one's own work as a member / leader in a team to manage Electronics / Instrumentation / Control and Automation projects and multidisciplinary environments.
6	Recognize the need for self and life-long learning, keeping pace with technological challenges in the broadest sense.

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4. PEO/PO Mapping:

PEO	PO					
I	1	2	3	1	3	3
II	3	3	3	3	3	3
III	3	-	3	3	3	2
IV	2	-	3	3	3	2
V	2	-	2	2	3	-

1,2,3,-, scale against the correlation PO's with PEO's

PROGRAM ARTICULATION MATRIX OF PG INSTRUMENTATION ENGINEERING (SPECIALIZATION IN INDUSTRIAL AUTOMATION)

		COURSE NAME	PO1	PO2	PO3	PO4	PO5	PO6
YEAR	SEMESTER I	Numerical Methods and Optimization Techniques	2	**-**	**2.5**	**2**	**-**	**1**
		Research Methodology and IPR	1	1	-	-	1	1
		Transducers and Smart Instruments	3	2	2	-	-	-
		Advanced Instrumentation Systems	2.3	2.3	2.3	2.3	2.6	2.8
		Advanced Digital Signal Processing	1	1.5	3	2	-	3
		Process Control: Design and Analysis	1	2	1	2.3	1	-
		Process Control and Instrumentation laboratory	1	2.3	2.5	2	2	-
		Embedded System Laboratory	1.3	-	1	1	-	-
	SEMESTER II	Advanced Process Control	1	2.5	3	3	1	1
		Instrumentation System Design	-	-	1	1	1	-
		Applied Machine Learning	1.16	2.7	1	1.3	2.6	2.5
		Professional Elective - State and Parameter Estimation	1	1.6	1	2.1	2	3
		Professional Elective - Linear and Nonlinear Systems Theory	3	3	3	3	3	1
		Professional Elective - Industrial Data Communication	2	1	2.6	1	-	-
		Professional Elective - Process Data Analytics	1.5	1.6	1.5	1.6	-	2.6
		Professional Elective - Optimal Control	1.6	2	1.5	2	-	2.6
		Professional Elective - Adaptive Control	3	-	1.4	1.5	-	-
		Professional Elective - Modeling and Simulation	3	1	2	3	-	-
		Professional Elective - Fault Detection and Diagnosis	2	-	1.6	-	-	3
		Professional Elective - Safety Instrumented Systems	3	3	2	2	-	-
		Professional Elective - Cyber Physical Systems	3	3	2.7	3	3	2

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		Industrial Automation Laboratory	1	2.7	1.14	1.57	1.8	1.7
YEAR II	SEMESTER III	Professional Elective - Thermal power plant Instrumentation	3	-	2.4	3	2	-
		Professional Elective - Industrial Drives and Control	2	2.75	2.2	2.3	-	-
		Professional Elective - Advanced Image Processing	2	-	2	1	-	2
		Professional Elective - Cyber Security for Industrial Automation	1	2	-	2	1.5	1
		Professional Elective - Advanced Medical Instrumentation	3	1	2	3	-	-
		Professional Elective - Instrumentation Standards	-	-	-	1	1	1
		Professional Elective – Nano sensors and MEMS	3	1	2	3	-	-
		Professional Elective - Industrial Safety Engineering	3	1	2	3	-	-
		Professional Elective - Cloud Computing Technologies	1	-	2	1	-	3
		Professional Elective – Robotics for Industrial Automation	1	2	1	2	3	2
		Professional Elective - Electromechanical System Design	1	2	1	2	3	3
		Project Phase I	2.6	2.7	2.8	3	2	2
	SEMESTER IV	Project Phase II	2.4	2.3	2.3	2.8	2.2	2.3

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CURRICULUM AND SYLLABUS I TO IV SEMESTERS

SEMESTER I

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MA3159	Numerical Methods and Optimization Techniques	FC	4	0	0	4	4
2.	RM3151	Research Methodology and IPR	RMC	2	1	0	3	3
3.	IN3101	Transducers and Smart Instruments	PCC	3	0	0	3	3
4.	IN3102	Advanced Instrumentation Systems	PCC	3	0	0	3	3
5.	IN3103	Advanced Digital Signal Processing	PCC	3	0	0	3	3
6.	IN3104	Process Control: Design and Analysis	PCC	3	0	0	3	3
PRACTICALS								
7.	IN3111	Process Control and Instrumentation Laboratory	PCC	0	0	4	4	2
8.	IN3112	Embedded System Laboratory	PCC	0	0	6	6	3
			TOTAL	**18**	**1**	**10**	**29**	**24**

SEMESTER II

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	IN3201	Advanced Process Control	PCC	3	0	4	7	5
2.	IN3202	Instrumentation System Design	PCC	3	0	0	3	3
3.	IN3203	Applied Machine Learning	PCC	3	0	0	3	3
4.		Professional Elective I	PEC	3	0	0	3	3
5.		Professional Elective II	PEC	3	0	0	3	3
PRACTICALS								
6.	IN3211	Industrial Automation Laboratory	PCC	0	0	6	6	3 Attested
			TOTAL	**15**	**0**	**10**	**25**	**20**

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SEMESTER III

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK L	T	P	TOTAL CONTACT PERIODS	CREDITS
THEORY								
1.		Professional Elective III	PEC	3	0	0	3	3
2.		Professional Elective IV	PEC	3	0	0	3	3
3.		Professional Elective V	PEC	3	0	0	3	3
PRACTICALS								
4.	IN3311	Project Work I	EEC	0	0	12	12	6
			TOTAL	**9**	**0**	**12**	**21**	**15**

SEMESTER IV

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK L	T	P	TOTAL CONTACT PERIODS	CREDITS
PRACTICALS								
1.	IN3411	Project Work II	EEC	0	0	24	24	12
			TOTAL	0	0	24	24	12

TOTAL NO. OF CREDITS: 71

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FOUNDATION COURSES (FC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			L	T	P		
1.	MA3159	Numerical Methods and Optimization Techniques	4	0	0	4	1

PROFESSIONAL CORE COURSES (PCC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			L	T	P		
1.	IN3101	Transducers and Smart Instruments	3	0	0	3	1
2.	IN3102	Advanced Instrumentation Systems	3	0	0	3	1
3.	IN3103	Advanced Digital Signal Processing	3	0	0	3	1
4.	IN3104	Process Control: Design and Analysis	3	0	0	3	1
5.	IN3111	Process Control and Instrumentation Laboratory	0	0	4	2	1
6.	IN3112	Embedded System Laboratory	0	0	6	3	1
7.	IN3201	Advanced Process Control	3	0	4	5	2
8.	IN3202	Instrumentation System Design	3	0	0	3	2
9.	IN3203	Applied Machine Learning	3	0	0	3	2
10	IN3211	Industrial Automation Laboratory	0	0	6	3	2
					TOTAL CREDITS	**31**	

RESEARCH METHODOLOGY AND IPR COURSES (RMC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			L	T	P		
1.	RM3151	Research Methodology and IPR	2	1	0	3	1
					TOTAL CREDITS	3	

PROFESSIONAL ELECTIVES

SEMESTER II

ELECTIVE I & II

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1	IN3001	State and Parameter Estimation	PEC	3	0	0	3	3
2	IN3002	Linear and Nonlinear Systems Theory	PEC	3	0	0	3	3
3	IN3003	Industrial Data Communication	PEC	3	0	0	3	3
4	IN3004	Process Data Analytics	PEC	3	0	0	3	3
5	IN3005	Optimal Control	PEC	3	0	0	3	3
6	IN3006	Adaptive Control	PEC	3	0	0	3	3
7	IN3007	Modelling and Simulation	PEC	3	0	0	3	3
8	IN3008	Fault Detection and Diagnosis	PEC	3	0	0	3	3
9	IN3051	Safety Instrumented Systems	PEC	3	0	0	3	3
10	CO3052	Cyber Physical Systems	PEC	3	0	0	3	3

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SEMESTER III

ELECTIVE III, IV and V

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1	IN3009	Thermal power plant Instrumentation	PEC	3	0	0	3	3
2	IN3010	Industrial Drives and Control	PEC	3	0	0	3	3
3	IN3011	Advanced Image Processing	PEC	3	0	0	3	3
4	IN3012	Cyber Security for Industrial Automation	PEC	3	0	0	3	3
5	IN3013	Advanced Medical Instrumentation	PEC	3	0	0	3	3
6	IN3014	Instrumentation Standards	PEC	3	0	0	3	3
7	IN3015	Nano sensors andMEMS	PEC	3	0	0	3	3
8	IN3016	Industrial Safety Engineering	PEC	3	0	0	3	3
9	IN3017	Cloud Computing Technologies	PEC	3	0	0	3	3
10	IN3018	Robotics for Industrial Automation	PEC	3	0	0	3	3
11	IN3019	Electromechanical System Design	PEC	3	0	0	3	3

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			L	T	P		
1	IN3311	Project Work I	0	0	12	6	3
2	IN3411	Project Work II	0	0	24	12	4
					TOTAL CREDITS	18	

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SUMMARY

	Name of the Programme: M.E					
	SUBJECT AREA	**CREDITS PER SEMESTER**				**CREDITS TOTAL**
		I	**II**	**III**	**IV**	
1.	FC	4	0	0	0	4
2.	PCC	17	14	0	0	31
3.	PEC	0	6	9	0	15
4.	RMC	3	0	0	0	3
5.	EEC	0	0	6	12	18
6.	**TOTAL CREDIT**	**24**	**20**	**15**	**12**	**71**

MA3159 NUMERICAL METHODS AND OPTIMIZATION TECHNIQUES

	L	T	P	C
	4	0	0	4

UNIT I ORDINARY DIFFERENTIAL EQUATIONS 12

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

UNIT II FINITE DIFFERECE METHOD FOR PARTIAL DIFFERENTIAL EQUATIONS 12

Parabolic equations: explicit and implicit finite difference methods, weighted average approximation - Dirichlet and Neumann conditions – Two dimensional parabolic equations – ADI method– Wave equation: Explicit scheme- Stability- Laplace and Poisson's equations in a rectangular region: Five point finite difference schemes, Leibmann's iterative methods.

UNIT III FINITE ELEMENT METHOD 12

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

UNIT IV LINEAR PROGRAMMING 12

Two variable LP model - Graphical solution - Simplex method - Special cases in the simplex method - Transportation and Assignment problem.

UNIT V DETERMINISTIC DYNAMIC PROGRAMMING 12

Recursive Nature of Dynamic Programming Computations - Forward and Backward Recursion - Selected Dynamic Programming Applications.

TOTAL: 60 PERIODS

OUTCOMES:

At the end of the course, students will be able to

CO1 Solve the simultaneous ordinary differential equations (Initial Value Problem) numerically.
CO2 Solve numerically set of Partial differential equations.
CO3 Solve the set of PDEs by finite element method.
CO4 Obtain the most optimal solution for a constrained problem.
CO5 Handle the Dynamic Programming problems using forward and backward recursion.

REFERENCES:

1. Burden. R. L. and Faires. J. D., "Numerical Analysis; Theory and Applications", India Edition, Cengage Learning, 2010.
2. Jain M.K., Iyengar S.R.K. and Jain R.K., Computational Methods for Partial Differential Equations, New Age International, 2nd Edition, New Delhi, 2016.
3. Morton K.W., and Mayers D.F., "Numerical Solution of Partial Differential Equations, Cambridge University Press, Second Edition, Cambridge, 2005.
4. Santosh K Gupta, "Numerical Methods for Engineers", New Age International (P) Limited, Publishers, New Delhi, 2014.
5. Sastry S.S., "Introductory Methods of Numerical Analysis", Prentice - Hall of India Pvt. Limited, 5th Edition, New Delhi, 2012.
6. Saumyen Guha and Rajesh Srivastava, "Numerical methods for Engineering and Science", Oxford Higher Education, New Delhi, 2010.
7. Taha H.A., "Operations Research: An Introduction", Pearson Education, Inc., 10th Edition, New Delhi, 2017.

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MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg.	**3**	**3**	**3**	**3**	**2**	**2**

RM3151 RESEARCH METHODOLOGY AND IPR **L T P C**
2 1 0 3

UNIT I RESEARCH PROBLEM FORMULATION 9

Objectives of research, types of research, research process, approaches to research; conducting literature review- information sources, information retrieval, tools for identifying literature, Indexing and abstracting services, Citation indexes, summarizing the review, critical review, identifying research gap, conceptualizing and hypothesizing the research gap

UNIT II RESEARCH DESIGN AND DATA COLLECTION 9

Statistical design of experiments- types and principles; data types & classification; data collection - methods and tools

UNIT III DATA ANALYSIS, INTERPRETATION AND REPORTING 9

Sampling, sampling error, measures of central tendency and variation,; test of hypothesis- concepts; data presentation- types of tables and illustrations; guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript; guidelines for wring thesis, research proposal; References – Styles and methods, Citation and listing system of documents; plagiarism, ethical considerations in research

UNIT IV INTELLECTUAL PROPERTY RIGHTS 9

Concept of IPR, types of IPR – Patent, Designs, Trademarks and Trade secrets, Geographical indications, Copy rights, applicability of these IPR; , IPR & biodiversity; IPR development process, role of WIPO and WTO in IPR establishments, common rules of IPR practices, types and features of IPR agreement, functions of UNESCO in IPR maintenance.

UNIT V PATENTS 9

Patents – objectives and benefits of patent, concept, features of patent, inventive steps, specifications, types of patent application; patenting process - patent filling, examination of patent, grant of patent, revocation; equitable assignments; Licenses, licensing of patents; patent agents, registration of patent agents.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, the student can
CO1: Describe different types of research; identify, review and define the research problem
CO2: Select suitable design of experiment s; describe types of data and the tools for collection of data
CO3: Explain the process of data analysis; interpret and present the result in suitable form
CO4: Explain about Intellectual property rights, types and procedures
CO5: Execute patent filing and licensing

REFERENCES:

1. Cooper Donald R, Schindler Pamela S and Sharma JK, “Business Research Methods”, Tata McGraw Hill Education, 11e (2012).
2. Soumitro Banerjee, “Research methodology for natural sciences”, IISc Press, Kolkata, 2022,
3. Catherine J. Holland, “Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets”, Entrepreneur Press, 2007.
4. David Hunt, Long Nguyen, Matthew Rodgers, “Patent searching: tools & techniques”, Wiley, 2007.
5. The Institute of Company Secretaries of India, Statutory body under an Act of parliament, “Professional Programme Intellectual Property Rights, Law and practice”, September 2013.

Attested

IN3101 TRANSDUCERS AND SMART INSTRUMENTS

	L	T	P	C
	3	0	0	3

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

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

UNIT II MEASUREMENT ERROR AND UNCERTAINTY ANALYSIS **9**

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

UNIT III SMART SENSORS **9**

Definition – Integrated smart sensors - Interface electronics - Design, sensing elements and parasitic effects, Signal Conditioning –Digital Conversion Method – Compensations-Microcontrollers and digital signal processors for smart sensors — Remote calibration – Smart Transducer Interface standard (IEEE 1451)- Interfacing Resistive and Inductive sensors to microcontrollers without ADC– Smart transmitters(HART enabled).

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- IC sensors – Optical sensors - Electro chemical sensors – RFIDs - Sensor nodes – Wireless Sensor network - Multisensor data fusion - Soft sensor - Lidar - Radar and its types- sensors used in smartphones

TOTAL : 45 PERIODS

COURSE OUTCOMES:

On successful completion of the course, students will be able to:

CO 1 Categorize and characterize a conventional transducer.

CO 2 Analyze and quantify the uncertainties in measurement data.

CO 3 Design smart sensors with special features.

CO 4 Acquire a comprehensive Knowledge of manufacturing techniques and design aspects of micro sensors and actuators.

CO 5 Keep abreast of latest sensor technology and advanced measurement methodologies.

CO 6 Suggest a proper transducer for an application.

REFERENCES:

1. Ernest O Doebelin and Dhanesh N Manik, “Measurement Systems Application and Design”, 6thEdition, 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.
6. Doebelin E.O. and Manik D.N., “Measurement Systems”, 6th, Tata McGraw Hill Education Pvt. Ltd., 2011.
7. Renganathan, S., "Transducer Engineering”, Allied Publishes, 2003.
8. Murthy, D.V.S., “Transducers and Instrumentation”, 2nd Edition, Prentice Hall of India Pvt. Ltd., New Delhi, 2011.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	-	-	-
CO2	3	2	2	-	-	-
CO3	3	2	2	-	-	-
CO4	3	2	2	-	-	-
CO5	3	2	2	-	-	-
CO6	3	2	2	-	-	-
AVg.	**3**	**2**	**2**	**-**	**-**	**-**

Note: 1-low, 2-medium, 3-high, ‘-“- no correlation

IN3102 ADVANCED INSTRUMENTATION SYSTEMS LT P C
3 0 0 3

UNIT I MEASUREMENT OF PROCESS PARAMETERS – TEMPERATURE AND PRESSURE 9

TEMPERATURE:
Definitions and standards – Resistance Temperature Detectors –Thermocouple- Radiation thermometers – Fiber optic temperature sensor– Temperature sensor selection, Installation and Calibration.

PRESSURE:
Units of pressure — Manometers- Elastic type pressure gauges - Electrical pressure transducers- Fiber optic pressure sensor Measurement of vacuum: McLeod gauge, Cold cathode type and hot cathode type ionization gauges – Pressure gauge selection, installation and calibration.

UNIT II MEASUREMENT OF PROCESS PARAMETERS – FLOW AND LEVEL FLOW 9
Variable head flow meters – positive displacement flow meters-variable area flow meters-Electrical type flow meters – Open channel flow measurement –Solid flow measurement. Mass flow meter, magnetic flow meter, vortex and ultrasonic

LEVEL
Float gauges – Displacer type – Bubbler system – Load cell – Conductivity sensors – Capacitive sensors – D/P methods - radar and guided radar – Ultrasonic level sensors –Solid level measurement.

UNIT III INSTRUMENTS FOR CHEMICAL ANALYSIS 9
Ion selective electrodes — pH and Conductivity measurement — UV Visible and IR Spectrometry- Gas & Liquid Chromatography – Mass Spectrometry- Oxygen analyzers for gas and liquid –CO,CO2 ,NO and SO Analyzers. dissolved oxygen, Total Suspended solids, turbidity

UNIT IV SAFETY INSTRUMENTATION & INSTRUMENTATION STANDARDS 9
Introduction to Safety Instrumented Systems – Process Hazards Analysis (PHA) – Safety Life Cycle – Control and Safety Systems - Safety Instrumented Function - Safety Integrity Level (SIL) – Selection, Verification and Validation of SIL.
Instrumentation Standards - significance of codes and standards — Introduction of various Instrumentation standards – interpretation and significance of specific standards - examples of usage of standards on specific applications.

UNIT V DOCUMENTATION IN PROCESS INDUSTRIES 9
Block Diagram of a Typical Process — Instrumentation Symbols, Abbreviations and Identification for Instruments: - Mechanical Equipment, Electrical Equipment, Instruments and Automation Systems - Process Flow Diagram (PFD) – Piping and Instrumentation Diagram (P&ID) - Instrument Lists and Specification – Logic Diagrams – Instrument Loop Diagrams - Instrument Hookup Diagrams – Typical Control /Rack Rooms Layout – Interpretation of Vendors Documents and Drawings.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

On successful completion of the course, students will be able to:

CO1 Understand the construction, working and calibration of temperature, pressure,flow and level sensors.

CO2 Understand the working principle of different chemical analyzers.

CO3 Select instruments for specific application.

CO4 Understand the role of Safety instrumented system and instrumentation standardsin the industry.

CO5 Analyze process hazards and apply risk assessment techniques for an industrial plant.

CO6 Design, develop, and interpret the documents used to define instruments and control systems for a typical project, including P&IDs, loop diagrams, instrument lists, logic diagrams, installation details, and location plans.

REFERENCES:

1. Doebelin, E.O. and Manik D.N., "Measurement systems Application and Design", 5th Edition, Tata McGraw-Hill Education Pvt. Ltd, 2009.
2. Braun, R.D., "Introduction to Instrumental Analysis", Pharma Book Syndicate, Singapore, 7th Edition 2012.
3. Paul Gruhn, P.E., CFSE and Harry Cheddie, P.E., "Safety Instrumented Systems: Design, Analysis, and Justification", 2nd Edition, ISA,2006.
4. Safety - ANSI/ISA84.00.01-2004, Part 1: Framework, Definitions, System Hardware and Software Requirements; ANSI/ISA84.00.01-2004, Part 2: Functional Safety: Safety Instrumented Systems for the Process Industry Sector; ANSI/ISA84.00.01-2004, Part 3: Guidance for the Determination of the Required Safety Integrity Levels-Informative
5. Patranabis, D. Principles of Industrial Instrumentation, Tata McGraw-Hill Publication, 2000.
6. B.G.Liptak, "Instrumentation Engineers Handbook (Process Measurement & Analysis)", Fourth Edition, Chilton Book Co, CRC Press, 2005. 4 Safety - ANSI/ISA84.00.01-2004, Part 1: Framework, Definitions, System Hardware and Software Requirements; ANSI/ISA84.00.01-2004.
7. Part 2: Functional Safety: Safety Instrumented Systems for the Process Industry Sector; ANSI/ISA84.00.01-2004.
8. Part 3: Guidance for the Determination of the Required Safety Integrity Levels- Informative6 Documentation Standards - ANSI/ISA5.4-1991 - Instrument Loop Diagrams; ANSI/ISA5.06.01-2007 - Functional Requirements Documentation for ControlSoftware Applications; ANSI/ISA20-1981 - Specification Forms for Process Measurement and Control Instruments, Primary Elements, and Control Valves.
9. 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.
10. Documentation Standards - ANSI/ISA5.4-1991 - Instrument Loop Diagrams; ANSI/ISA5.06.01-2007 - Functional Requirements Documentation for Control Software Applications; ANSI/ISA20-1981 - Specification Forms for Process Measurement and Control Instruments, Primary Elements, and Control Valves.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	3	3	3	3	3
CO2	1	3	3	3	3	3
CO3	3	1	3	3	2	2
CO4	3	1	3	1	3	3
CO5	3	3	1	3	2	3
CO6	3	3	1	1	3	3
AVg.	**2.3**	**2.3**	**2.3**	**2.3**	**2.6**	**2.8**

Note: 1-low, 2-medium, 3-high, '-"- no correlation

IN3103	ADVANCED DIGITAL SIGNAL PROCESSING	L	T	P	C
		3	0	0	3

UNIT I REVIEW OF DIGITAL SIGNALS, SYSTEMS AND FILTERS 9

Discrete Time Fourier Transform – Definition, Properties, Inverse DTFT, Frequency response of LTI systems using DTFT - Discrete Fourier Transform — Definition, Properties, Circular Convolution, Fast Fourier Transform - Decimation in time and decimation in frequency Radix 2 FFT algorithm, Inverse DFT using FFT algorithm.

UNIT II RANDOM SIGNAL PROCESSING AND SPECTRUM ESTIMATION 9

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

UNIT III LINEAR ESTIMATION AND PREDICTION 9

Maximum likelihood criterion - efficiency of an estimator - Least mean squared error criterion - Wiener filter - Discrete Wiener Hoff equations - Recursive estimators - Kalman filter - Linear prediction, prediction error - whitening filter, inverse filter — Levinson-Durbin recursion algorithm, Lattice realization.

UNIT IV ADAPTIVE FILTERS 9

Digital filters – Introduction, Butterworth IIR filter design, FIR filter design using Rectangular, Barlett and Raised cosine windows. Adaptive filters – Introduction - Steepest descent adaptive filter - Widrow Hopf LMS adaptive algorithm - Adaptive channel equalization - Adaptive echo chancellor - Adaptive noise cancellation - RLS adaptive filters - Exponentially weighted RLS - Sliding window RLS - Simplified IIR LMS adaptive filter.

UNIT V MULTIRATE DIGITAL SIGNAL PROCESSING 9

Introduction to Multi rate signal processing, Decimation and Interpolation by an integer factor, Quadrature Mirror Filters, Subband coding, Polyphase realization, Limitations of Fourier transform, Time-frequency representation, Short time Fourier transform – Definition, Fourier Representation, Filter bank implementation, Introduction to Wavelet transform – Relation to Multirate filter banks, Time frequency representation, Wavelet System and its characteristics,CWT and DWT basis functions.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

On successful completion of the course, students will be able to:

- **CO1** Apply the knowledge of mathematics, science, and engineering for the analysis and design of digital systems
- **CO2** Identify, formulate and solve engineering problems in the area of random signal processing and spectrum estimation.
- **CO3** Estimate the states of the stochastic system using Kalman filter.

Attested

CO4 Design adaptive filters using recursive algorithms with realistic constraints.
CO5 Analyze multi rate systems and filter banks
CO6 Select the analysis tools and design algorithms for the implementation of adaptive systems

REFERENCES:

1. Monson Hayes, “Statistical Digital Signal Processing and Modeling”, Wiley, Reprint, 2008.
2. Proakis, J.G., and Manolakis, D.G., “Digital Signal Processing Principles, Algorithms and Applications”, 4th edition, Pearson Education, 2007
3. P. P. Vaidyanathan, “Multi rate Systems and Filter Banks”, Prentice Hall Signal ProcessingSeries, Impearson, 2008
4. Tulay Adali and Simon Haykin, “Adaptive Signal Processing, Next Generation Solutions”, John Wiley and Sons, 2010.
5. Monson Hayes, “Digital Signal Processing”, 2nd edition, McGraw Hill, 2011.
6. Ali Ahammad Shoukat Choudhury, Sirish L. Shah and Nina F.Thornhill, “Diagnosis of Process Nonlinearities and Valve Stiction: Data Driven Approaches”, Springer, 2008.
7. NPTEL Video Lecture series on, “Advanced Digital Signal Processing” by Prof. V.M. Gadre, IIT Bombay.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	-	-	-	-	-
CO2	1	1	-	-	-	-
CO3	1	2	-	-	-	-
CO4	1	-	-	2	-	-
CO5	1	-	-	-	-	-
CO6	-	-	3	-	-	3
AVg.	**1**	**1.5**	**3**	**2**	**-**	**3**

Note: 1-low, 2-medium, 3-high, ‘-“- no correlation

IN3104 **PROCESS CONTROL: DESIGN AND ANALYSIS** **L T P C**
3 0 0 3

UNIT I PROCESS DYNAMICS **9**

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

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

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

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

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

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

UNIT IV MULTIVARIABLE SYSTEMS & MULTI-LOOP REGULATORY CONTROL **9**

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

UNIT V MULTIVARIABLE REGULATORY CONTROL & CASE –STUDIES **9**

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

TOTAL : 45 PERIODS

COURSE OUTCOMES:

On successful completion of the course, students will be able to:

CO1 Apply knowledge of mathematics, science, and engineering to the build and analyze models for flow, level, and thermal processes.

CO2 Determine the advanced features supported by the Industrial Type PID Controller.

CO3 Design, tune and implement SISO P/PI/PID Controllers to achieve desired Performance for various processes.

CO4 Analyze Multivariable Systems and Design Multi-variable and Multi-loop Control

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Schemes for various processes namely four-tank system, pH process, bio-reactor, distillation column.

CO5 Identify, formulate, and solve problems in the process control domain.

CO6 Analyze various advanced control schemes and recommend the right control strategy for a given application in accordance with the industrial requirement.

REFERENCES:

1. B.Wayne Bequette, "Process Control: Modeling, Design, and Simulation", Prentice Hall of India, 2004.
2. Dale E. Seborg , Duncan A. Mellichamp , Thomas F. Edgar, and Francis J. Doyle, III "Process Dynamics and Control", John Wiley and Sons, 3rd Edition, 2010.
3. Jose A. Romagnoli and Ahmet Palazoglu , "Introduction to Process Control", CRC Press, Taylor and Francis Group, Second Edition, First Indian Reprint, 2012.
4. Coleman Brosilow and Babu Joseph, "Techniques of Model-based Control", Prentice Hall International Series, PTR, New Jersey, 2002.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	3	-	3	-	-
CO2	1	1	-	3	-	-
CO3	1	-	1	1	1	-
CO4	1	-	1	3	1	-
CO5	1	-	-	3	1	-
CO6	1	-	-	1	-	-
AVg.	**1**	**2**	**1**	**2.3**	**1**	**-**

Note: 1-low, 2-medium, 3-high, '-"- no correlation

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IN3111 PROCESS CONTROL AND INSTRUMENTATION LABORATORY

L	T	P	C
0	0	4	2

List of Experiments

1. (a).Calibration of ammeter, voltmeter and wattmeter using multifunction calibrator.
   (b).Calibration and configuration of smart transmitter using HART communicator.
   (c).Calibration and configuration of transmitters using loop calibrator.
2. Interfacing different types of flow meters with PC using DAQ.
3. Interpretation of P & ID (ISA S5.1)
4. Simulation of Lumped/ Distributed Parameter System.
5. Identification of Transfer function model of a Typical Industrial Process.
6. Design and Implementation of Practical Forms of PID Controller on the simulated model of aTypical Industrial Process.
7. Design and Implementation of Feed forward and Cascade control schemes on the simulatedmodel of a Typical Industrial Process.
   (a) Analysis of MIMO system.
   (b) Design and implementation of Multi-loop PID and Multivariable PID control schemes onthe simulated model of a Typical Industrial Process.
8. Control of flow process using industrial type PID controller.
9. PC based control of Level process.
10. Design and implementation of Gain scheduled Adaptive controller on the simulated modelof a variable area tank process.
11. Design and implementation of a Fuzzy Logic Control scheme on the simulated model of aTypical Industrial Process.

TOTAL : 60 PERIODS

COURSE OUTCOMES:
On successful completion of the course, students will be able to:

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

scheme, model based control scheme and fuzzy logic control scheme.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	3	3	3	3	-
CO2	1	1	-	1	-	-
CO3	1	3	-	1	-	-
CO4	1	-	1	3	1	-
CO5	1	-	3	3	1	-
CO6	1	-	3	1	3	-
AVg.	**1**	**2.3**	**2.5**	**2**	**2**	**-**

Note: 1-low, 2-medium, 3-high, '-"- no correlation

IN3112 **EMBEDDED SYSTEM LABORATORY**

L	T	P	C
0	0	6	3

LIST OF EXPERIMENTS

Practical Module – 1 Introduction to Embedded System

Objective(s)

- To introduce embedded system and its fundamental building blocks.
- To make the students familiar with the architectural features of microcontrollers and the basic concept of embedded C programming.

Demonstration

- Building the source code for the required application on an Integrated Development Environment and loading the same onto the chosen microcontroller through In System Programming (ISP).

Experiment(s)

- Implementing Arithmetic and logical operations using Embedded C.
- Implementing conditional and loop control operations using Embedded C.

Assignment(s)

- Building a simple calculator.
- Development of simple applications using recursion.

Practical Module – 2 Interrupts & Timers

Objective(s)

- To make the students understand the concept of interrupts and timers.
- To enable the students to effectively use interrupts and timers for embedded control applications

Demonstration

- Frequency measurement using Timer/counter
- Interfacing limit switch using hardware interrupts.

Experiment(s)

- Design of a programmable Timer.
- Implementing conditional and loop control operations using Embedded C.

Assignment(s)

- Generation of interrupt using Timer to activate/deactivate field devices.

Practical Module - 3 ADC/DAC

Objective(s)

- To make the students understand the operational features of various types of ADCs / DACs.
- To provide an insight over data acquisition to carry out signal processing.

Demonstration

- Interfacing ADC/DAC with microcontroller using Proteus Design Suite.
- Acquisition of a continuous signal and reconstruction of its sampled version.

Experiment(s)

- Interfacing analog transmitter with microcontroller.
- Interfacing final control element with microcontroller.
- Design of a multichannel data acquisition system.

Assignment(s)

- Design of a smart transmitter.

Practical Module – 4 Communication Modules

Objective(s)

- To make the students familiar with synchronous(I^2C&SPI) and asynchronous (UART) communication protocols
- To impart knowledge on establishing communication between microcontrollers and peripherals using appropriateserial communication protocols.

Demonstration

- Remote data transmission using both synchronous and asynchronous communication protocols. RS485

Experiment(s)

- I^2C based DAC interface and SPI based ADC interface.
- Remote transmission of field transmitter data to PC.

Assignment(s)

- Interfacing RTC with microcontroller using I^2C interface.
- Interfacing EEPROM with microcontroller using SPI interface.

Practical Module – 5 Wireless Communication Modules

Objective(s)
- To introduce various wireless communication protocols
- To facilitate the students to acquire field parameters through wireless communication Protocols

Demonstration
- Establishing communication between microcontroller and PC using Zigbee module.

Experiment(s)
- Remote transmission of sensor data using Zigbee protocol.

Assignment(s)
- Remote monitoring of process using Zigbee protocol.

Practical Module – 6 RTOS Concepts

Objective(s)
- To facilitate the students to realize the power of RTOS and its operational characteristics
- To enable the students to perform task scheduling and establish inter-task communication

Demonstration
- Implementing multitasks on an RTOS enabled embedded system

Experiment(s)
- Design of a multichannel data acquisition system with time, interrupt, task and memory management features.

Assignment(s)
- Implementation of a real-time control application (Inverted pendulum or dc motor etc.) using RTOS.

Practical Module – 7 Design of Feedback Control System

Objective(s)
- To impart knowledge on the development of embedded control system
- To make the students realize the challenges in an embedded system design for a given application

Demonstration
- Implementation of a simple feedback controller on the temperature process.

Experiment(s)
- Realization of PID Control Algorithm in microcontroller

Assignment(s)
- Design and Implementation of PID controller on the temperature process.

Practical Module – 8 IoT Enabled Embedded Systems

Objective(s)
- To impart knowledge on the inherent features of IoT for

Embedded applications

Demonstration	• To enable the students to carry out IoT enabled data acquisition • Building an IoT application using Python
Experiment(s)	• IoT enabled field sensing
Assignment(s)	• Development of IoT enabled transmitter.

Practical Module – 9 PSoC for Embedded Control Applications

Objective(s)	• To make the students understand the configurable features of PSoC • To facilitate the students to exploit the built-in facilities of PSoC for control applications
Demonstration	• Programming the PSoC using PSoC programmer.
Experiment(s)	• Data acquisition and control using PSoC.
Assignment(s)	• Reconstruction of an analog signal from its digital equivalent.

Practical Module - 10 DSP Processor for Embedded Systems

Objective(s)	• To make the students understand the salient features of Digital Signal Processors
Demonstration	• Realizing the power of Digital Signal Processors for real-time processing requirements
Experiment(s)	• Design and implementation of FIR filter using Microcontroller and DSP
Assignment(s)	• Design and implementation of IIR filter using Microcontroller and DSP

Practical Module – 11 Image Processing based Embedded Applications

Objective(s)	• To make the students understand the use of image processing in embedded control applications • To design and implement embedded image processing applications
Demonstration	• Camera interfacing with Raspberry Pi
Experiment(s)	• Image acquisition and processing using Raspberry Pi
Assignment(s)	• Design of a field surveillance system.

Practical Module – 12 Mini Project

• Design of an industrial type PID controller.

Attested

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TOTAL : 90 PERIODS

COURSE OUTCOMES:

On successful completion of the course, students will be able to:

CO1 Realize the functions of various constitutional modules of an embedded system.
CO2 Formulate suitable strategies for interfacing real world sensors and actuators with microcontrollers.
CO3 Recognize the operational behaviour of RTOS based systems and use them efficiently in design environments.
CO4 Identify, formulate and apply embedded control strategies for industrial applications.
CO5 Infer the concept of IoT and demonstrate its power in real world applications.
CO6 Devise design strategies for industrial embedded applications.

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	-	1	-	-	-
CO2	2	-	1	1	-	-
CO3	-	-	1	-	-	-
CO4	1	-	1	1	-	-
CO5	-	-	1	1	-	-
CO6	1	-	1	-	-	-
AVg.	1.3	-	1	1	-	-

Note: 1-low, 2-medium, 3-high, '-"- no correlation

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IN3201 **ADVANCED PROCESS CONTROL** **L T P C**

3 0 4 5

UNIT I CONTROL OF TIME-VARYING AND NONLINEAR SYSTEMS 9

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

UNIT II OPTIMAL CONTROL & FILTERING 9

Introduction – Performance Measure for optimal control problem – LQR and LQT for Continuous Time & Discrete Time – Introduction to Optimal Filtering – Discrete Kalman Filter – LQG

UNIT III FRACTIONAL ORDER SYSTEM & CONTROLLER 9

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

UNIT IV H-INFINITY CONTROLLER 9

Introduction – Norms for Signals – Robust Stability – Robust Performance – Small Gain Theorem – Optimal H2 Controller Design - H-Infinity Controller Design –– Effects of Weighting Functions in H-Infinity Control.

UNIT V FAULT DIAGNOSIS AND FAULT-TOLERANT CONTROL 9

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

TOTAL : 45 PERIODS

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List of Experiments

1. Identification and validation of Linear Dynamic model (Black Box) of a Processusing Non-Parametric Methods.
2. Identification and validation of Linear Dynamic model (Black Box) of a Processusing Parametric Methods.
3. Identification and Validation of a Grey-box model of a Temperature Process
4. Estimation of State Variables of a series RLC circuit using Kalman Filter
5. Estimation of Parameters of a ARX model using Recursive Least Squares Algorithm
6. Design and Implementation of a soft-sensor using Multi-Variate Statistical Methods
7. Design and Implementation of Fractional-order PID Controller on the TransferFunction model of a Process.
8. Design and Implementation of a Robust-PID Controller on the Transfer Functionmodel of a Process.
9. Design and Implementation of Model Reference Adaptive Controller on thesimulated model of a variable area tank process.
10. Design and Implementation of Dynamic Matrix Control Scheme on the simulatedmodel of a Temperature Process.
11. Design and Implementation Optimal Control Schemes (Fuel/Energy/Time) onthe simulated model of a system.
12. Identification of a Non-Linear Dynamic model (Black Box) of a Process usingMachine Learning Algorithms

TOTAL : 60 PERIODS

COURSE OUTCOMES :

On successful completion of the course, students will be able to:

CO 1 Apply knowledge of mathematics, science, and engineering to build, analyze and solve models for linear and nonlinear systems using first principles and system identification techniques.

CO 2 Design and implement adaptive controllers, such as gain-scheduled adaptive controller,Model-reference adaptive controller and Self-tuning controller.

CO 3 Design and implement optimal and robust controllers for the given process.

CO 4 Analyze Fractional-order systems, Fractional-order- controller and Design controller for fractional order systems.

CO 5 Design and implement H2 and H-infinity Controllers.

CO 6 Use the Techniques such as Principal component Analysis, state observer to detect and diagnose faults in sensors and actuators and to design soft-sensors using Multi-Variate Statistical Methods.

REFERENCES:

1. K.J. Astrom and B.J.Wittenmark, "Adaptive Control", Pearson Education, Second Edition, 2008.
2. Donald E.Kirk, "Optimal Control Theory – An Introduction", Dover Publications, Inc. Mineola, New York, 2012
3. D.Xue, Y.Q.Chen, D.P.Atherton, "Linear Feedback Control Analysis and Design with MATLAB, Advances in Design and Control", Society for Industrial and Applied Mathematics, 2008.
4. R. Isermann, "Fault-Diagnosis Systems: An Introduction from Fault Detection to Fault Tolerance", Springer, 2006.
5. Ikonen, E., & Najim, K. (2001). Advanced process identification and control. CRC Press.
6. Ljung, L. (1998). System identification. In Signal analysis and prediction (pp. 163-173). Boston, MA: Birkhäuser Boston.
7. Nelles, O., & Nelles, O. (2020). Nonlinear dynamic system identification (pp. 831-891). Springer International Publishing.

MAPPING COURSE OUTCOMES WITH PROGRAMME OUTCOMES

CO	PO					
	1	2	3	4	5	6
1	1	3	3	3	1	1
2	1	2	3	3	1	1
3	1	2	3	3	1	1
4	1	2	3	3	1	1
5	1	3	3	3	1	1
6	1	3	3	3	1	1
AVg.	1	2.5	3	3	1	1

Note: 1-low, 2-medium, 3-high, '-"- no correlation

IN3202 **INSTRUCTION SYSTEM DESIGN**

L	T	P	C
3	0	0	3

UNIT I DESIGN OF SIGNAL CONDITIONING CIRCUITS **9**

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

UNIT II DESIGN OF TRANSMITTERS **9**

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

UNIT III DESIGN OF DATA LOGGER AND PID CONTROLLER **9**

Micro - controller based Data Logger - Design of PC based Data Acquisition Cards - Design of ON / OFF Controller using Analog Circuits - Electronic PID Controller - Microcontroller Based PID Controller.

UNIT IV DESIGN OF ALARM AND ANNUNCIATION CIRCUIT **9**

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

UNIT V ORIFICE AND CONTROL VALVE SIZING **9**

Orifice, Venturi and flow nozzle Sizing: BS1047/ ISO5167 - Liquid, Gas and steam services – Control valve sizing ISA75 – Liquid, Gas and steam Services and Standards. Thermowell ASME PTC 19.3

TOTAL : 45 PERIODS

COURSE OUTCOMES:

On successful completion of the course, students will be able to:

CO 1 Design signal conditioning circuits for temperature sensors, V/I and I/V converters.
CO 2 Design, fabricate and test smart transmitters.
CO 3 Design, fabricate and test PID controllers.
CO 4 Carry out orifice and control valve sizing for Liquid/Steam Services.
CO 5 Exposure to simulation tools such as MATLAB.
CO 6 Deign PLC and alarm circuits.

REFERENCE BOOKS:

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

Attested

5. Thakore and Bhatt ,"Introduction to Process Engineering and Design" , TATA McGraw-Hill,2007.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	-	1	-	-	-
CO2	-	-	1	1	1	-
CO3	-	-	1	1	-	-
CO4	-	-	-	-	-	-
CO5	-	-	-	-	-	-
CO6		-	-	1	1	-
AVg.	**-**	**-**	**1**	**1**	**1**	**-**

Note: 1-low, 2-medium, 3-high, '-"- no correlation

IN3203 **APPLIED MACHINE LEARNING**

L	T	P	C
3	0	0	3

UNIT I INTRODUCTION TO MACHINE LEARNING **9**

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

UNIT II DATA PREPROCESSING **9**

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

UNIT III SUPERVISED LEARNING **9**

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

UNIT IV UNSUPERVISED LEARNING **9**

Introduction – Clustering:- Partitioning Methods:- K-means algorithm - Hierarchical clustering – Fuzzy Clustering – Clustering High-Dimensional Data:- Problems – Challenges – Subspace Clustering – Biclustering –Case studies.

UNIT V BAYESIAN LEARNING **9**

Probability based clustering – The Expectation Maximization Algorithm – Bayesian Classification – Bayesian Networks – Learning Bayesian Networks – Hidden Markov Models- Case studies

TOTAL : 45 PERIODS

COURSE OUTCOMES:

On successful completion of the course, students will be able to:

CO 1 understand the basic theory underlying machine learning.

CO 2 understand a range of machine learning algorithms along with their strengths & weaknesses and able to select appropriate ML algorithm.

CO 3 formulate machine learning problems corresponding to different applications.

CO 4 apply machine learning algorithms to solve problems of moderate complexity.

CO 5 understand the work reported in the research papers in the area of machine learning.

CO 6 select suitable software tools, understand and develop codes for machine learning algorithms to solve moderately complex problems.

REFERENCES:

1. Stephen Marsland, Machine Learning: An Algorithmic Perspective, Second Edition CRC Press, 2015.
2. Ian H. Witten, Eibe Frank, Mark A. Hall, Data Mining: Practical Machine Learning Tools and Techniques, Elsevier, 3rd Edition 2011.
3. Jiawei Han, Micheline Kamber, Jian Pei, Data Mining: Concepts and Techniques: Concepts and Techniques, Elsevier, 2011.
4. Ferdinand van der Heijden, Robert Duin, Dick de Ridder, David M. J. Tax, Classification, Parameter Estimation and State Estimation: An Engineering Approach Using MATLAB, John Wiley & Sons, 2005.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	1	2	3	3
CO2	1	3	1	1	3	3
CO3	1	3	1	1	1	2
CO4	1	2	1	2	3	2
CO5	1	3	1	1	3	2
CO6	1	2	1	1	3	3
AVg.	**1.16**	**2.7**	**1**	**1.3**	**2.6**	**2.5**

Note: 1-low, 2-medium, 3-high, '-"- no correlation

IN3211 INDUSTRIAL AUTOMATION LABORATORY **LT P C**
0 0 6 3

LIST OF EXPERIMENTS

Practical Module – 1: Study of PLC architecture and Field Device Interface Modules(AI, AO, DI, DO Modules).

Objective(s) Impart knowledge on PLC architecture including CPU, I/O module, connecting I/O modules (DI/DO/AI/AO modules) to CPU, Power supply module and Communication module & Hot swapping, Industrial certifications.

Demonstration Configuration of a PLC.

Experiment(s)
1. Study of DI/DO/AI/AO modules of all PLCs.
2. Installation & Configuration of I/O modules
3. Understanding one of the PLC Control panels wiring diagram and creating a control panel layout

Assignment(s)
1. Comparison of all PLCs in the lab.
2. Market survey of the recent PLCs and comparison of their features with the PLCs available in the lab.

Practical Module – 2: Programming PLC using IEC 61131-3 PLC Programming Languages

Objective(s) To introduce students on how to program using all five IEC-61131-3 programming languages.

Demonstration Procedure for Programming PLC using all IEC 61131-3 PLC Programming Languages. - Case Study - Filling and draining of liquid in a single tank.

Experiment(s) 1. Implementation of Alarm-Annunciator sequences (ISA 18.1 Standard) using all IEC 61131-3 PLC Programming Languages.

Assignment(s)
1. Implementation of Traffic light control sequences using all IEC 61131-3 PLC Programming Languages
2. Exercises covering all instruction sets/Function Blocks etc.

Practical Module – 3 Interfacing Analog/Digital Input/output Devices with Industrial Type PLC.

Objective(s) To introduce students on how to Interface transmitters, limit switches, final control elements with PLC.

Demonstration How to Interface field devices to a PLC – Case Study: How to interface field devices available in the filling and draining of liquid in a single tank experimental test setup to a PLC

Experiment(s) 1. Interfacing Level Transmitter and Control valve with PLC.

Attested

2. Interfacing Limit switches and a Pump (relay with dry contact and wet contact) with PLC.

Assignment(s) 1.Interfacing Temperature Transmitter and Heater with PLC.

2.Interfacing Flow Transmitter and Variable-speed pump with PLC.

Practical Module – 4 Closed loop control of a typical process using PLC.

Objective(s) To introduce students on how to configure PID control block to achieve closed loop control.

Demonstration Configuration of PID Function Block

Experiment On-line Monitoring and Control of Level Process using PLC

Assignment(s) On-line Monitoring and Control of Processes such as Flow, Temperature and Pressure, using PLC.

Practical Module – 5 HMI/ SCADA Programming

Objective(s) SCADA/HMI development, configuration of face plates, creation of logs, Transmitter data trend displays, linking oftags with graphics

Demonstration HMI/SCADA development for the Pressure Control Station.

Experiment(s) HMI/SCADA development for the Process Control Training Plant(Level/Flow Process)

Assignment(s) HMI/SCADA development for a Typical Industrial Processes

Practical Module - 6. Study of Safety PLC

Objective(s) To make the students understand the fundamental differences between Safety PLC and Standard PLC.

Demonstration(s) Procedure for Programming Safety PLC and Configuration of Fail-safe I/O Modules.

Experiment(s) 1.Study of Fail-safe I/O modules.

2. Implementation of Alarm-Annunciator sequences (ISA 18.1Standard) in Safety PLC

Assignment(s) Market survey of the recent safety PLCs and comparison of their features with the PLC available in the lab.

Practical Module-7 Architecture of DCS

Objective(s) Impart knowledge on DCS architecture including CPU, I/O module, connecting I/O modules (DI/DO/AI/AO modules) to CPU, Power supply module and Communication module & Hot swapping, Industrial certification

Demonstration Configuration of DCS.

Experiment(s) 1. Study of AI, AO, DI, DO, H1-interface modules of all DCSs.

Attested

2. Installation & Configuration of I/O modules.

3. Understanding any one of the DCS Control panels wiring diagram and creating a control panel layout.

Assignment(s) Market survey of the recent DCSs and comparison of their features with the DCSs available in the lab.

Practical Module-8 Interfacing of field devices with DCS.

Objectives To introduce students on how to Interface transmitters, limit switches, final control elements with DCS

Demonstration
1. How to Interface Level transmitter and Flow Transmitter in the Process Control Training Plant to aDCS.
2. How to interface Limit Switches, Pumps (MCC, pumps interlocks like running feedback, overload trip),solenoids and Control valves in the Process Control Training Plant to a DCS.

Experiment(s)
1. Interfacing Temperature Transmitter and Variable Speed Pump to a DCS

2.Configuration of face plates, creation of logs and trend displays

Assignment(s) 1. Interfacing Temperature Transmitter and Heater and Variable

Speed Pump with Pump Controller to a DCS.

Practical Module-9. Realization of control schemes for typical processes using DCS.

Objective To introduce students on how to configure PID control block to achieve closed loop control.

Demonstration Configuration of PID Function Block and PID Faceplate.

Experiment On-line Monitoring and Control of Level Process using Distributed Control System.

Assignment(s) 1. On-line Monitoring and Control of Process such as Flow, Temperature and Pressure, using Distributed Control System.

Practical Module-10 Interfacing smart field devices with DCS.

Objective To introduce students on how to Interface smart field devices(HART/Foundation Field bus) with DCS.

Demonstration Demonstration of 'PID control' in field devices.

Experiment(s) Design and Implementation of Feedback control scheme (FF-PID) for the level process using DCS.

Assignment(s) Market survey: Industrial Data Networks

Attested

Practical Module – 11 Interfacing Wireless Transmitter to a DCS.
Objective(s) To introduce students on how to Interface Wireless transmitters and how to configure HART communicator.

Demonstration How to Interface Wireless field devices to a DCS?

Experiment(s) Interfacing Wireless HART enabled Transmitters to a DCS.

Assignment(s) Comparison of Wireless HART and ISA 100.11a Communication Protocols.

Practical Module - 12 IoT based monitoring of Level/Flow process.

Objective(s) Introduction to IoT based monitoring.

Demonstration Configuration of IoT gateway.

Experiment(s)
1. Interfacing transmitters to DCS through IoT gateway.
2. Cloud based Monitoring of level/flow process.

Assignment(s) Cloud based Monitoring of temperature process.

TOTAL : 90 PERIODS

COURSE OUTCOMES:

On successful completion of the course, students will be able to:

CO 1 Understand all the important components such as PLC, SCADA, DCS, I/O modulesand field devices of an industrial automation system.

CO 2 develop PLC program in different languages for industrial applications.

CO 3 Gain hands on experience in interfacing transmitters and final control elements with PLC and DCS.

CO 4 Configure and develop Feedback Control Schemes using PLC and DCS.

CO 5 select and use most appropriate automation technologies for a given application.

CO 6 configure IoT gateway for any industrial process using DCS.

CO 7 interface smart filed devices(HART /FF enabled field devices)with DCS and gain knowledge on the recent developments in industrial data networks.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	2	1	2	2	2
CO2	1	2	1	1	2	2
CO3	1	3	1	2	2	2
CO4	1	3	1	2	2	2
CO5	1	3	1	2	1	1
CO6	1	3	2	1	2	1
CO7	1	3	1	1	2	2
AVg.	**1**	**2.7**	**1.14**	**1.57**	**1.8**	**1.7**

Note: 1-low, 2-medium, 3-high, '-"- no correlation

IN3311	PROJECT WORK I	L	T	P	C
		0	0	12	6

A Project topic must be selected either from research literature or the students themselves may propose suitable topics in consultation with their guides. The aim of the project work is to deepen Comprehension of principles by applying them to a new problem which may be the design /fabrication of Sensor/Actuator/Controller, a research investigation, a computer or management project or a design problem, or a simulation work.
A project report is required at the end of the semester. The project work is evaluated jointly by external and internal examiners constituted by the Head of the Department based on oral presentation and the project report.

TOTAL : 180 PERIODS

COURSE OUTCOMES:
On successful completion of the course, students will be able to:
CO 1 Find solution for complex engineering problems applying the engineering knowledge.
CO 2 Formulate and analyze complex engineering problem.
CO 3 Select and apply software tools required to solve the formulated problem.
CO 4 Identify and find solution to societal issues.
CO 5 Build solutions to the formulated problem using multidisciplinary engineering knowledge.
CO 6 Communicate the engineering activity and to do effective documentation of the work carried out.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	3	1	2
CO2	3	3	3	3	1	2
CO3	2	-	2	3	-	-
CO4	2	-	-	-	3	3
CO5	3	-	2	3	3	1
CO6	-	3	-	-	2	-
AVg.	2.6	2.7	2.8	3	2	2

Note: 1-low, 2-medium, 3-high, '-"- no correlation

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IN3411 **PROJECT WORK II** **L T P C**

0 0 24 12

A Project topic must be selected either from research literature or the students themselves may propose suitable topics in consultation with their guides. The aim of the project work is to deepen Comprehension of principles by applying them to a new problem which may be the design /fabrication of Sensor/Actuator/Controller, a research investigation, a computer or management project or a design problem, or a simulation work.

A project report is required at the end of the semester. The project work is evaluated jointly by external and internal examiners constituted by the Head of the Department based on oral presentation and the project report.

TOTAL : 360 PERIODS

COURSE OUTCOMES:

On successful completion of the course, students will be able to:

CO 1 Formulate, analyze and find solution for complex engineering problems applying the engineering knowledge.

CO 2 Select and apply software tools required to solve the formulated problem.

CO 3 Identify and find solution to societal issues.

CO 4 Build solutions to the formulated problem using multidisciplinary engineering knowledge.

CO 5 Communicate the engineering activity and to do effective documentation of the work carried out.

CO 6 Use the knowledge obtained from project to engage in life -long learning.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	3	1	2
CO2	2	-	2	3	-	-
CO3	2	-	-	-	3	3
CO4	3	-	2	3	3	1
CO5	-	3	-	-	2	-
CO6	2	2	2	2	2	3
AVg.	**2.4**	**2.3**	**2.3**	**2.8**	**2.2**	**2.3**

Note: 1-low, 2-medium, 3-high, '-"- no correlation

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IN3001 STATE AND PARAMETER ESTIMATION

L	T	P	C
3	0	0	3

UNIT I KALMAN UPDATE BASED FILTERS & PARTICLE FILTER 9

Review of Matrix Algebra and Matrix Calculus and Probability Theory – Least Square Estimation – Luenberger Observer - 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 - 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 – Adaptive Neuro-Fuzzy Inference System(ANFIS) - Introduction to Support Vector Regression

UNIT V PRACTICAL ASPECTS OF IDENTIFICATION 9

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

TOTAL : 45 PERIODS

COURSE OUTCOMES

On successful completion of the course, students will be able to:

CO 1 design and implement state estimation schemes.
CO 2 develop various models (Linear & Nonlinear) from the experimental data.
CO 3 select a suitable model and parameter estimation algorithm for the identification of systems.
CO 4 carry out the verification and validation of identified model.
CO 5 gain expertise on using the model for prediction and simulation purposes and for developing suitable control schemes.
CO 6 compare various estimation techniques.

REFERENCES:

1. Dan Simon, "Optimal State Estimation Kalman, H-infinity and Non-linear Approaches", John Wiley and Sons, 2006.
2. Arun K. Tangirala, "Principles of System Identification: Theory and Practice", CRC Press,2014.
3. F. Van der Heijden, R.P.W. Duin, D. de Ridder and D.M.J. Tax, Classification, Parameter

Estimation and State Estimation, An Engineering Approach Using MATLAB, John Wiley &Sons Ltd., 2004.
4. W.T.Miller, R.S.Sutton and P.J.Webrose, “Neural Networks for Control”, MIT Press, 1996.
5. C.Cortes and V.Vapnik, “Support-Vector Networks, Machine Learning”, 1995.
6. Karel J. Keesman, “System Identification an Introduction”, Springer, 2011.
7. Tao Liu, Furong Gao, “Industrial Process Identification and control design, Step-test and relay-experiment-based methods”, Springer- Verilog London Ltd, 2012.
8. Lennart Ljung, “System Identification: Theory for the user”, Second edition, Prentice Hall,1999.

MAPPING OF Cos WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	2	1	2	-	-
CO2	1	2	1	2	-	-
CO3	1	1	1	2	-	-
CO4	1	-	1	2	-	-
CO5	-	-	1	3	2	3
CO6	1	-	1	2	2	3
Avg.	**1**	**1.6**	**1**	**2.1**	**2**	**3**

Note: 1-low, 2-medium, 3-high, ‘-“- no correlation

IN3002 LINEAR AND NONLINEAR SYSTEMS THEORY LT P C
3 0 0 3

UNIT I STATE SPACE APPROACH 9
Review of state model for systems – Non-uniqueness of state model – Role of Eigen values and Eigenvectors – State transition matrix and its properties – free and forced responses – State Diagrams – minimal realization – balanced realization.

UNIT II STATE FEEDBACK CONTROL AND STATE ESTIMATOR9 9
Controllability and Observability – Stabilizability and Detectability – Kalman Decomposition – State Feedback Control – Pole placement technique – Full order and Reduced Order Observers

UNIT III NON-LINEAR SYSTEMS 9
Types of Non-Linearity – Typical Examples – Phase plane analysis (analytical and graphical methods) – Limit cycles – Equivalent Linearization – Describing Function Analysis, Derivation of Describing Functions for different non-linear elements.

UNIT IV STABILITY OF NON-LINEAR SYSTEMS 9
Stability concepts – BIBO and Asymptotic stability – Stability Analysis by DF method – Lyapunov Stability Criteria – Krasovski's method – Variable Gradient Method – Popov's Stability Criterion – Circle Criterion

UNIT V NON-LINEAR SYSTEMS ANALYSIS 9
Bifurcation Behavior of Single ODE Systems: - Motivation, Illustration of Bifurcation Behavior and Types of Bifurcations – Bifurcation Behavior of Two-State Systems: - Dimensional Bifurcations in the Phase-Plane, Limit Cycle Behavior and Hopf Bifurcation – Introduction to Chaos: The Lorenz Equations, Stability Analysis of the Lorenz Equations, Numerical Study of the Lorenz Equations, Chaos in Chemical Systems and Other Issues in Chaos

TOTAL : 45 PERIODS

COURSE OUTCOMES :
On successful completion of the course, students will be able to:

CO 1 Analyze the time-invariant systems in state space form whether the system is stabilizable, controllable, observable and detectable.
CO 2 Implement the state feedback controller and state observers.
CO 3 Analyze the singular points and construct phase trajectory using delta and 47unctional methods.
CO 4 Potential to 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.
CO 5 Familiarize with the non-linear behaviors such as Limit cycles, input multiplicity and output multiplicity, Bifurcation and Chaos.
CO 6 identify the different types of non-linearity existing in the system.

REFERENCES:

1. K.Ogata, "Modern Control Engineering", Prentice Hall, Fifth Edition, 2012.
2. M.Gopal, "Digital Control and State Variable Methods: Conventional and Intelligent

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Control Systems", Third Edition, Tata Mc-Graw Hill, 2009.
3. B.W.Bequette, "Process Control: Modeling, Design and Simulation", Prentice Hall International series in Physical and Chemical Engineering Sciences, 2003.
4. Steven E. LeBlanc, Donald R. Coughanowr, "Process Systems Analysis and Control", Third Edition, Chemical Engineering series, McGraw-Hill Higher Education, 2009.
5. T.Thyagarajan and D.Kalpana, "Linear and Non-Linear System Theory", First Edition, CRC Press, Taylor and Francis, 2021.

MAPPING OF Cos WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	3	1
CO2	3	3	3	3	3	1
CO3	3	3	3	3	3	1
CO4	3	3	3	3	3	1
CO5	3	3	3	3	3	1
CO6	3	3	3	3	3	1
Avg.	**3**	**3**	**3**	**3**	**3**	**1**

Note: 1-low, 2-medium, 3-high, '-"- no correlation
The average value of this course to be used for program articulation matrix.

IN3003 INDUSTRIAL DATA COMMUNICATION

L T P C	
3 0 0 3	

UNIT I DATA NETWORK AND INTERNET FUNDAMENTALS 9

ISO/OSI Reference model – TCP/IP Protocol Stack – UDP – Transport Layer Security [Network security and cryptography] – Virtual Private Network – EIA 232 interface standard – EIA 485 interface standard – CAN [Controller Area Network] and CAN FD – Media access protocol: Command/response, CSMA/CD –– IEEE 802.3 – Bridges –Routers –Gateways– Standard ETHERNET configuration

UNIT II MODBUS AND HART 9

Evolution of industrial data communication standards – MODBUS:- Protocol structure, Function codes – HART communication protocol, Communication modes, HART Networks, HART commands, HART applications & Troubleshooting

UNIT III PROFIBUS AND FF 9

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

UNIT IV OPC AND INDUSTRIAL ETHERNET 9

OPC– Physical layer – Data link layer – Operating characteristics, Industrial Ethernet: Introduction – 10Mbps Ethernet – 100Mbps Ethernet- Gigabit Ethernet

UNIT V WIRELESS COMMUNICATION 9

Wireless sensor networks: Hardware components – energy consumption of sensor nodes – Network architecture – sensor network scenario. Wireless MAC Standards– IEEE 802.11- IEEE 802.15.4 – Zigbee Wireless HART – Wireless Standard for Process Industry – ISA100 – Introduction to Industrial IOT – Low Power Wide Area Network (LPWAN), Wi-Fi, low power Bluetooth for IoT and Industrial applications

TOTAL : 45 PERIODS

COURSE OUTCOMES:

On successful completion of the course, students will be able to:

CO 1 Acquire breadth of knowledge on Industrial data networking framework, their evolution associated hardware and software.

CO 2 Analyze and select proper protocol for device level and control level integration.

CO 3 Establish/design networking for process control applications and industrial automation.

CO 4 compare and choose a specific protocol for the given architecture.

CO 5 Select and use the most appropriate networking technologies and standards for a given application.

CO 6 Explore the requirements of an industry and provide a wired or wireless solution for installing Industrial data network.

Attested

REFERENCES:

1. Mackay, S., Wright,E., Reynders,D., and Park,J., "Practical Industrial Data Networks: Design, Installation and Troubleshooting", Newnes Publication,1st edition, Elsevier, 2004.
2. Buchanan,W., "Computer Busses: Design and Application", CRC Press, 2000.
3. Bela G. Liptak, "Instrument Engineers' Handbook, Volume 3 : Process Software and Digital Networks", 4th Edition, CRC Press, 2011.
4. Kurose James F., Ross Keith W , "Computer Networking: A Top-Down approach", Pearson Publications ,7th Edition,2016.
5. Bowden, R., "HART Application Guide", HART Communication Foundation, 1999.
6. Berge, J., "Field Buses for Process Control: Engineering, Operation, and Maintenance", ISA Press, 2004.
7. Lawrence (Larry) M. Thompson and Tim Shaw, "Industrial Data Communications", 5th Edition ,ISA Press, 2015.
8. NPTEL Lecture notes on," Computer Networks" by Department of Electrical Engineering, IIT Kharagpur.
9. High Performance Browser Networking, Ilya Grigorik [Former Network Google Engineer and Freely available online – https://hpbn.co/].

MAPPING OF Cos WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	2	1	-	-
CO2	2	1	2	1	-	-
CO3	2	1	3	1	-	-
CO4	2	1	3	1	-	-
CO5	2	1	3	1	-	-
CO6	2	1	3	1	-	-
Avg.	**2**	**1**	**2.6**	**1**	**-**	**-**

Note: 1-low, 2-medium, 3-high, '-"- no correlation

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IN3004 **PROCESS DATA ANALYTICS** **LT P C**
3 0 0 3

UNIT I INTRODUCTION 9

Introduction to Process data analytics and Statistical learning – Review of Linear Algebra Concepts – Review of Probability & Statistics – Design of experiments – Industrial case studieson factorial experiments.

UNIT II REGRESSION 9

Linear Regression:- Simple Linear Regression, Multiple Linear Regression -K-nearest neighbors regression – Practical Consideration in the Regression Model – Validation methods to assess model quality:-The validation set approach, Leave-One-Out Cross Validation, k-Fold CrossValidation – Bias-variance Trade-off for k-Fold Cross Validation.

UNIT III LINEAR MODEL SELECTION & REGULARIZATION 9

Subset Selection: - Best Subset Selection, Step-wise Selection and Choosing the Optimal Model – Shrinkage Methods: - LASSO, Ridge regression, Elastic nets – Dimension reduction Methods:- Principal Components Regression, Partial Least Squares.

UNIT IV SUPERVISED LEARNING WITH REGRESSION AND CLASSIFICATION TECHNIQUES 9

Logistic regression– Linear Discriminant Analysis – Quadratic Discriminant Analysis – Regression & Classification Trees – Support Vector Machines – Random forests, Bagging andboosting –Deep Learning.

UNIT V APPLICATIONS 9

Process data analysis for system identification (under open and closed loops) – Controller Performance Monitoring – Principal components analysis (PCA) for Process Monitoring and Partial Least Squares (PLS) for soft-sensor design – Data-based causality analysis for identification of process topology.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

On successful completion of the course, students will be able to:

CO 1 Apply Design of Experiments for Problem solving and Process Troubleshooting.
CO 2 select the right choice of regression method for a given application.
CO 3 select the right choice of classification method for a given application.
CO 4 Apply System Identification, Process &Performance Monitoring.
CO 5 analyze alarm data, process data and process connectivity information.
CO 6 carry out data driven analysis and process modeling.

REFERENCES:

1. Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, An Introduction to Statistical

Learning with Applications in R, Springer Texts in Statistics, 2013.
2. Ethem Alpaydin, Introduction to Machine Learning, MIT Press, 2013.
3. Thomas A. Runkler, Data Analytics: Models and Algorithms for Intelligent Data Analysis, Springer Vieweg, 2nd Edition, 2016.
4. Arun K. Tangirala, Principles of System Identification – Theory and Practice, CRC Press, 2018.
5. Huang, B. and Shah, S.L., Performance Assessment of Control Loops: Theory and Applications, Springer-Verlag,2007.
6. Fan Yang, Ping Duan, Sirish L Shah, Tongwen Chen,Capturing Connectivity and Causality in Complex Industrial Processes, Springer, 2014.

MAPPING OF Cos WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	-	-	2	-	-
CO2	-	1	1	1	-	-
CO3	1	2		-	-	2
CO4	2	2	2	1	-	3
CO5	-	-	-	1	-	3
CO6	-	-	-	3	-	-
Avg.	**1.5**	**1.6**	**1.5**	**1.6**	**-**	**2.6**

Note: 1-low, 2-medium, 3-high, '-"- no correlation

IN3005 **OPTIMAL CONTROL** **L T P C**
3 0 0 3

UNIT I CALCULUS OF VARIATIONS AND OPTIMAL CONTROL 9

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

UNIT II LINEAR QUADRATIC OPTIMAL CONTROL SYSTEM 9

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

UNIT III DISCRETE TIME OPTIMAL CONTROL SYSTEMS 9

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

UNIT IV PONTRYAGIN MINIMUM PRINCIPLE 9

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

UNIT V CONSTRAINED OPTIMAL CONTROL SYSTEMS 9

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

TOTAL : 45 PERIODS

COURSE OUTCOMES:

On successful completion of the course, students will be able to:

CO1 explain different type of optimal control problems such as time-optimal, fuel optimal, energy optimal control problems.

CO2 design Linear Quadratic Regulator for Time-invariant and Time-varying Linear system (Continuous time and Discrete-time systems).

CO3 design optimal controller using Dynamic Programming Approach and H-J-B equation.

CO4 Explain the Pontryagin Minimum Principle.

CO5 design optimal controller in the presence of state constraints and time optimal controller.

REFERENCES:

1. Donald E. Kirk, Optimal Control Theory – An Introduction, Dover Publications, Inc. Mineola, New York, 2012.
2. D. Subbaram Naidu, Optimal Control Systems, CRC Press, New York, 2003.
3. Frank L. Lewis, Draguna Vrabie, Vassilis L. Syrmos, Optimal Control, 3rd Edition, Wiley Publication, 2012.

Attested

MAPPING OF Cos WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	-	1	-	-	-
CO2	-	2	1	2	-	2
CO3	2	-	2	-	-	3
CO4	2	2	2	-	-	3
CO5	-	2	-	2	-	-
Avg.	**1.6**	**2**	**1.5**	**2**	**-**	**2.6**

Note: 1-low, 2-medium, 3-high, '-"- no correlation

IN3006 **ADAPTIVE CONTROL** **L T P C**
3 0 0 3

UNIT I INTRODUCTION **9**

Introduction – Adaptive Schemes – The adaptive Control Problem – Applications- Parameterestimation:-LS, RLS: and ERLS

UNIT II GAIN SCHEDULING **9**

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

UNIT III DETERMINISTIC SELF-TUNING REGULATORS **9**

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

UNIT IV STOCHASTIC AND PREDICTIVE SELF-TUNING REGULATORS **9**

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

UNIT V MODEL – REFERENCE ADAPTIVE SYSTEM **9**

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

TOTAL : 45 PERIODS

COURSE OUTCOMES

CO1 Ability to understand and apply the estimation algorithm to estimate the parameters of the process.

CO2 Ability to understand the basic concepts to master the techniques of adaptive control.

CO3 Ability to use appropriate software tools for design of adaptive controllers and analysis of the process.

CO4 Ability to identify, formulate, analyze engineering problems and carry out research by designing suitable adaptive schemes for complex instrumentation problem.

CO5 Ability to apply the concepts to design adaptive control for multidisciplinary problem.

CO6 Ability to make use of the techniques for self and lifelong learning to keep in pace with the new technology.

REFERENCES:

1. K.J. Astrom and B. J. Wittenmark, “Adaptive Control”, Second Edition, Pearson Education Inc., 2008.
2. T. Soderstorm and Petre Stoica, “System Identification”, Prentice Hall International (UK) Ltd., 1989.
3. Lennart Ljung, “System Identification: Theory for the User”, Second Edition, Prentice Hall, 1999.

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MAPPING OF Cos WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	-	2	2	-	-
CO2	-	-	2	1	-	-
CO3	-	-	1	-	-	-
CO4	3	-	1	-	-	-
CO5	-	-	1	-	-	-
CO6	3	-	-	-	-	-
AVg.	**3**	**-**	**1.4**	**1.5**	**-**	**-**

Note: 1-low, 2-medium, 3-high, '-"- no correlation

IN3007 MODELLING AND SIMULATION

	L	T	P	C
	3	0	0	3

UNIT I SYSTEMS AND PROCESSES 9

Systems and processes: Static and dynamic systems - Lumped and distributed systems - Conservative and Non-conservative systems - Time invariant and time variant systems – Linear and nonlinear systems – Reversible and irreversible process - Work, energy and power - Mathematical analogies.

UNIT II INTRODUCTION TO MATHEMATICAL MODELLING 9

Modelling techniques: White box models, Black box models, Grey box models, Assumptions and Approximations, Continuous and discrete models., Linear/Polynomial regression, Multiple regression, Mathematical modelling using dimensional analysis, Applications of mathematical models.

UNIT III SYSTEM MODELLING USING ORDINARY DIFFERENTIAL EQUATIONS 9

Types of ordinary differential equations: Linear and nonlinear ODE's, Homogeneous and non-homogeneous ODE's, Autonomous and non-autonomous ODE's., - Order of the differential equation, Modelling of exponential growth and decay, Modelling of oscillatory dynamics, Degrees of freedom. Modelling using material balance and energy balance - examples.

UNIT IV BLACK BOX MODELLING 9

Experimental Design –Linear and nonlinear models for system identification, Parameter estimation methods: Least squares method, Recursive Least squares method, Maximum Likelihood estimation, Dynamic Programming.

UNIT V SIMULATION AND ANALYSIS 9

Solving Equations on the Computer: Euler's Method, Runge–Kutta method, Adams predictor corrector method. - Stability Analysis: Fixed points of a system, Phase Plane Analysis, Liapunov's Direct Method.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On successful completion of the course, students will be able to:

CO1 Explain and compare various types of systems and processes.
CO2 Select appropriate modelling approaches for given problems.
CO3 Formulate mathematical models using first principles.
CO4 Develop mathematical models using experimental data.
CO5 Solve and analyze the developed models.
CO6 Develop models for engineering problems from a variety of settings in general mathematical forms.

REFERENCES:

1. Giordano, F., Fox, W. P., & Horton, S. A first course in mathematical modeling. Nelson Education., 2013.
2. Kapur, J. N. Mathematical Modelling. New Age International., 1988.
3. Johansson, RSystem modeling & identification. Prentice-Hall.,1993.
4. Ljung, L. System identification. John Wiley & Sons, Inc.,1999.

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5. Andrews, J. G., & McLone, R. R. (Eds.) Mathematical modelling. London: Butterworths.,1976.
6. Kamalanand, K., & Jawahar, P. Mathematical modelling of systems and analysis. PHI Learning Pvt. Ltd.,2018.
7. Butcher, J. C. Numerical methods for ordinary differential equations. John Wiley & Sons.,2016.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	3	-	-
CO2	3	1	2	3	-	-
CO3	3	1	2	3	-	-
CO4	3	1	2	3	-	-
CO5	3	1	2	3	-	-
CO6	3	1	2	3	-	-
AVg.	**3**	**1**	**2**	**3**	**-**	**-**

1- low, 2-medium, 3-high, '-"- no correlation

IN3008 **FAULT DETECTION AND DIAGNOSIS** **LT P C**
3 0 0 3

UNIT I INTRODUCTION & ANALYTICAL REDUNDANCY CONCEPTS 9

Introduction – Types of faults and different tasks of Fault Diagnosis and Implementation – Different approaches to FDD: Model free and Model based approaches-Introduction-Mathematical representation of Faults and Disturbances: Additive and Multiplicative types – Design of Residual generator – Residual specification and Implementation.

UNIT II FAULT DETECTION AND DIAGNOSIS USING LIMIT CHECKING AND PROCESS IDENTIFICATION METHODS 9

Limit Checking of absolute values – Trend Checking – Change detection using binary thresholds – adaptive thresholds – Change detection with Fuzzy thresholds – Fault detection using Process Identification methods and Principle Component Analysis.

UNIT III FAULT DETECTION AND DIAGNOSIS USING PARITY EQUATIONS 9

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

UNIT IV FAULT DIAGNOSIS USING STATE ESTIMATORS 9

Introduction – Review of State Estimators – Fault Detection and Diagnosis using Generalized Likelihood Ratio Approach and Marginalized Likelihood Ratio Approach

UNIT V CASE STUDIES 9

Fault detection and diagnosis of DC Motor Drives – Fault detection and diagnosis of a Centrifugal pump-pipe system – Fault detection and diagnosis of an automotive suspension and the tire pressures - Automatic detection, quantification and compensation of valve stiction.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

On successful completion of the course, students will be able to:

CO1 explain different approaches to Fault Detection and Diagnosis.
CO2 detect faults using Limit Checking, Parameter estimation methods, Principle Component Analysis.
CO3 design and detect sensor and actuators faults using structured residual approach as well as directional structured residual approach.
CO4 design and detect faults in sensor and actuators using GLR and MLR based approaches.
CO5 detect and quantify and compensate stiction in Control valves.
CO6 detect and diagnose the fault.

REFERENCES:

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

2. Rolf Isermann, "Fault-Diagnosis Systems an Introduction from Fault Detection to Fault Tolerance", Springer Verlag, 2006.
3. Steven X. Ding, "Model based Fault Diagnosis Techniques: Schemes, Algorithms, and Tools", Springer Publication, 2012.
4. Hassan Noura, Didier Theilliol, Jean-Christophe Ponsart and Abbas Chamseddine, "Fault-Tolerant Control Systems: Design and Practical Applications", Springer Publication,2009.
5. Blanke, Mogens; Kinnaert, Michel; Lunze, Jan; Staroswiecki, Marcel ,"Diagnosis andFault-Tolerant Control", Springer, 2015.
6. Ali Ahammad Shoukat Choudhury, Sirish L. Shah and Nina F. Thornhill, "Diagnosis of Process Non linearities and Valve Stiction: Data Driven Approaches", Springer, 2008.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	-	2	-	-	3
CO2	-	-	2	-	-	-
CO3	-	-	1	-	-	-
CO4	-	-	1	-	-	-
CO5	-	-	2	-	-	-
CO6	-	-	2	-	-	3
AVg.	**2**	**-**	**1.6**	**-**	**-**	**3**

Note: 1-low, 2-medium, 3-high, '-"- no correlation

IN3051 **SAFETY INSTRUMENTED SYSTEMS**

L	T	P	C
3	0	0	3

UNIT I INTRODUCTION 9

Safety Instrumented System (SIS): need, features, components, difference between basic process control system and SIS - Risk: how to measure risk, risk tolerance, Safety integrity level, safety instrumented functions - Standards and Regulation – HSE-PES, AICHE-CCPS, IEC-61508, ANSI/ISA-84.00.01-2004 (IEC 61511 Mod) & ANSI/ISA – 84.01-1996, NFPA 85, API RP 556, API RP 14C, OSHA (29 CFR 1910.119 – Process Safety Management of Highly Hazardous Chemicals – SIS design cycle - Process Control vs Safety Control.

UNIT II PROTECTION LAYERS AND SAFETY REQUIREMENT SPECIFICATIONS 9

Prevention Layers: Process Plant Design, Process Control System, Alarm Systems, Procedures, Shutdown/Interlock/Instrumented Systems (Safety Instrumented Systems – SIS), Physical Protection - Mitigation Layers: Containment Systems, Scrubbers and Flares, Fire and Gas (F&G) Systems, Evacuation Procedures - Safety specification requirements as per standards, causes for deviation from the standards.

UNIT III SAFETY INTEGRITY LEVEL (SIL) 9

Evaluating Risk, Safety Integrity Levels, SIL Determination Method : As Low As Reasonably Practical (ALARP), Risk matrix, Risk Graph, Layers Of Protection Analysis (LOPA) – Issues related to system size and complexity –Issues related to field device safety – Functional Testing.

UNIT IV SYSTEM EVALUATION 9

Failure Modes, Safe/Dangerous Failures, Detected/Undetected Failures, Metrics: Failure Rate, MTBF, and Life, Degree of Modeling Accuracy, Modeling Methods: Reliability Block Diagrams, Fault Trees, Markov Models - Consequence analysis: Characterization of potential events, dispersion, impacts, occupancy considerations, consequence analysis tools - Quantitative layer of protection analysis: multiple initiating events, estimating initiating event frequencies and IPL failure probabilities.

UNIT V CASE STUDY 9

SIS Design check list - Case Description: Furnace/Fired Heater Safety Shutdown System: Scope of Analysis, Define Target SILs, Develop Safety Requirement Specification (SRS), SIS Conceptual Design, Lifecycle Cost Analysis, Verify that the Conceptual Design Meets the SIL, Detailed Design, Installation, Commissioning and Pre-startup Tests, Operation and Maintenance Procedures.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

On successful completion of the course, students will be able to:

CO1 understand Non-SIS layers of protection and the need for SIS in process industries.
CO2 state the associated SIS standards.
CO3 implement hazard analysis & risk assessment to identify process hazards & risks.
CO4 determine the target SIL & safety requirements specifications

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CO5 develop detailed SIS design, installation & operation.
CO6 implement SIS analysis & design for a furnace/ fired heater system.

REFERENCES:

1. Paul Gruhn and Harry L. Cheddie," Safety Instrumented systems: Design, Analysis and Justification", ISA, 2nd edition, 2018.
2. Eric W. Scharpf, Heidi J. Hartmann, Harlod W. Thomas, "Practical SIL target selection: Risk analysis per the IEC 61511 safety Lifecycle", exida 2nd Edition 2016.
3. William M. Goble and Harry Cheddie, "Safety Instrumented Systems Verification: Practical Probabilistic Calculations" ISA, 2005.
4. Edward Marszal, Eric W. Scharpf, "Safety Integrity Level Selection: Systematic Methods Including Layer of Protection Analysis", ISA, 2002.
5. Standard - ANSI/ISA-84.00.01-2004 Part 1 (IEC 61511-1 Mod) "Functional Safety: Safety Instrumented Systems for the Process Industry Sector - Part 1: Framework, Definitions, System, Hardware and Software Requirements", ISA, 2004.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	-	-	-	-	-
CO2	3	-	-	-	-	-
CO3	-	-	2	2	-	-
CO4	-	-	-	2	-	-
CO5	-	3	2	-	-	-
CO6	-	-	2	-	-	-
AVg.	**3**	**3**	**2**	**2**	**-**	**-**

Note: 1-low, 2-medium, 3-high, '-"- no correlation

CO3052 **CYBER PHYSICAL SYSTEMS** **LT P C**
3 0 0 3

UNIT I INTRODUCTION **9**

Introduction-key features of cyber physical systems- Continuous dynamics: Newtonian mechanics-actor models-properties of systems-feedback control-Discrete dynamics: Discrete systems- Finite state machines.

UNIT II SYNCHRONOUS AND ASYNCHRONOUS MODEL **9**

Synchronous model: Reactive components-properties of components-composing components- synchronous design, Asynchronous model- asynchronous processes- asynchronous design primitives- coordination protocols.

UNIT III SAFETY AND LIVENESS REQUIREMENT **9**

Safety specifications- verifying invariants- Enumerative search- Temporal logic- Model checking- reachability analysis- proving live-ness

UNIT IV TIMED MODEL AND REAL-TIME SCHEDULING **9**

Timed processes- Timing based protocols: Timing-Based Distributed Coordination-Audio Control Protocol- Timed automata: Model of Timed Automata-Region Equivalence-Matrix- Based Representation for Symbolic Analysis, Real-time scheduling

UNIT V HYBRID SYSTEMS **9**

Classes of Hybrid Systems-Hybrid dynamic models: Hybrid Processes-Process Composition- Zeno Behaviors-Stability- designing hybrid systems- linear hybrid automata.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

1. Ability to apply mathematical knowledge and basis of science and engineering to develop model for continuous and discrete systems.
2. Ability to develop synchronous and asynchronous models
3. Ability to assess the safety requirements of the cyber physical systems
4. Ability to apply automata for modeling timed systems
5. Ability to analyze the stability of hybrid systems

REFERENCES:

1. Rajeev Alur, Principles of cyber-physical systems, The MIT press, 2015.
2. E. A. Lee and S. A. Seshia, Introduction to Embedded Systems - A Cyber-PhysicalSystems Approach, Lulu.com, First Edition, Jan 2013.
3. Sang C.Suh , U.John Tanik and John N.Carbone , Applied Cyber-Physical systems,Springer,2014

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MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	1	-	-	-
CO2	1	2	2	-	-	-
CO3	1	-	-	2	1	-
CO4	-	-	-	2	2	1
CO5	-	-	-	1	1	1
AVg.	**1.33**	**2**	**1.5**	**1.66**	**1.33**	**1**

Note: 1-low, 2-medium, 3-high, '-"- no correlation

IN3009 THERMAL POWER PLANT INSTRUMENTATION

L	T	P	C
3	0	0	3

UNIT I BASICS OF THERMAL POWER PLANT **9**

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

UNIT II BOILER MODELING **9**

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

UNIT III BOILER CONTROL **9**

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

UNIT IV MEASUREMENTS AND ANALYZERS IN POWER PLANTS **9**

Steam pressure Control – Speed control of turbine – Alternator- Monitoring voltage and frequency –Operation of several units in parallel- Synchronization.

Flue gas oxygen analyzer – analysis of impurities in feed water and steam – dissolved oxygen analyzer

UNIT V OPTIMIZATION OF THERMAL POWER PLANT OPERATION **9**

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

TOTAL : 45 PERIODS

COURSE OUTCOMES (COs)

On successful completion of the course, students will be able to:

CO 1 Define the role of various subsystems with their function available in Thermal power plant.

CO 2 Illustrate the procedural steps to obtain the mathematical model of various units in Thermal power plant.

CO 3 Interpret conventional and advanced control concepts and theirs implementation in various processes available in thermal power plant.

CO 4 Identify the parameters to be monitored, measured, analyzed and controlled in thermal power plants.

CO 5 Calculation and optimization of Boiler efficiency by including various losses in thermal power plant.

REFERENCES:

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

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	-	3	3	2	-
CO2	3	-	2	3	2	-
CO3	3	-	3	3	-	-
CO4	3	-	2	3	-	-
CO5	3	-	2	3	-	-
AVg.	**3**	**-**	**2.4**	**3**	**2**	**-**

Note: 1-low, 2-medium, 3-high, '-"- no correlation

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IN3010	INDUSTRIAL DRIVES AND CONTROL	L	T	P	C
		3	0	0	3

UNIT I INTRODUCTION TO ELECTRIC DRIVES **9**

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

UNIT II MODELING OF DC AND AC MACHINES **9**

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

UNIT III CONTROL OF DC DRIVES **9**

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

UNIT IV CONTROL OF AC DRIVES **9**

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

UNIT V ADVANCED CONTROL OF AC DRIVES **9**

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

TOTAL : 45 PERIODS

COURSE OUTCOMES:

On successful completion of the course, students will be able to:

- **CO1** understand motor-load system dynamics and stability, modern drive system objectives and fundamentals of dc and ac motors.
- **CO2** model both dc and ac motors in various conventional methods.
- **CO3** design and analyze both the converter and chopper driven dc drives
- **CO4** understand the conventional control techniques of ac drives and will have the ability to design and analyze such system.
- **CO5** Explain advanced high performance control strategies for ac drives and emerging technologies in electric drives.
- **CO6** have a comprehensive exposure to emerging technologies like AI in the field of electric drives.

REFERENCES:
1. G.K.Dubey, “Power Semiconductor Controlled Drives,” Prentice Hall International, New Jersey, 1989.
2. Paul .C.Krause, Oleg wasynczuk and Scott D.Sudhoff, “Analysis of Electric Machinery and Drive Systems”, 2nd edition , Wiley-IEEE Press, 2013.
3. Bimal K Bose, “Modern Power electronics and AC Drives”, Pearson education Asia, 2002.
4. R .Krishnan, “Electrical Motor Drives- Modeling, Analysis and Control”, Prentice Hall of India Pvt Ltd., 2nd Edition, 2003.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	-	-	-
CO2	-	-	3	2	-	-
CO3	-	3	3	3	-	-
CO4	-	3	1	2	-	-
CO5	-	3	2	-	-	-
CO6	2	-	-	-	-	-
AVg.	**2**	**2.75**	**2.2**	**2.3**	**-**	**-**

Note: 1-low, 2-medium, 3-high, ‘-“- no correlation

IN3011 ADVANCED IMAGE PROCESSING

L	T	P	C
3	0	0	3

UNIT I DIGITAL IMAGE FUNDAMENTALS AND TRANSFORMS 9

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

UNIT II IMAGE PREPROCESSING AND ENHANCEMENT 9

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

UNIT III IMAGE RESTORATION AND COMPRESSION 9

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

UNIT IV IMAGE SEGMENTATION AND ANALYSIS 9

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

UNIT V APPLICATIONS OF IMAGE PROCESSING 9

Recognition based on Decision Theoretic methods-Structural Recognition- Linear Discriminant Analysis – Optimization Techniques in Recognition - Applications in particle size measurement – Flow measurement - Food processing – Case studies.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

On successful completion of the course, students will be able to:

CO1 understand the technical terms associated with image and video processing.

CO2 select the appropriate preprocessing techniques for manipulation of images.

CO3 utilize the different approaches of image enhancement, segmentation and analysis techniques.

CO4 apply image processing techniques in both the spatial and frequency domains.

CO5 use appropriate software tools(Example: Matlab, Open CV and Python) for image and video processing.

CO6 apply the imaging techniques to various applications.

Attested

REFERENCE BOOKS

1. Rafael C.Gonzalez and Richard E.Woods, “Digital Image Processing” Prentice Hall, Third

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

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	-	-	-	-	-
CO2	2	-	2	-	-	-
CO3	-	-	2	1	-	-
CO4	-	-	-	1	-	-
CO5	-	-	-	1	-	-
CO6	-	-	-	-	-	2
AVg.	**2**	**-**	**2**	**1**	**-**	**2**

Note: 1-low, 2-medium, 3-high, ‘-“- no correlation

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IN3012 CYBER SECURITY FOR INDUSTRIAL AUTOMATION

L	T	P	C
3	0	0	3

UNIT I INTRODUCTION 9

Industrial security environment-Industrial automation and control system(IACS) culture Vs IT Paradigms- Cyberattacks: Threat sources and steps to successful cyber attacks.

UNIT II RISK ANALYSIS 9

Risk identification, classification and assessment, Addressing risk: Cyber security Management System (CSMS), organizational security, physical and environmental security, network segmentation, access control, risk management and implementation.

UNIT III ACCESSING THE CYBERSECURITY OF IACS 9

Identifying the scope of the IACS- generation of cyber security information-identification of vulnerabilities- risk assessment-evaluation of realistic threat scenarios- Gap assessment-capturing Ethernet traffic- documentation of assessment results.

UNIT IV CYBERSECURITY DESIGN AND IMPLEMENTATION 9

Cyber security lifecycle- conceptual design process- detailed design process- firewall design-remote access design- intrusion detection design.

UNIT V TESTING AND MAINTENANCE 9

Developing test plans- cyber security factory acceptance testing- site acceptance testing-network and application diagnostics and troubleshooting- cyber security audit procedure- IACS incident response.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

On successful completion of the course, students will be able to:

CO1 apply basis of science and engineering to understand Industrial security environment and cyberattacks.

CO2 analyze and assess risks in the industrial environment

CO3 access the cybersecurity of IACS

CO4 design and implement cybersecurity

CO5 test and troubleshoot the industrial network security system

REFERENCES:

1. Ronald L and Krutz, Industrial Automation and Control System Security Principles, ISA, 2016.
2. Edward J.M. Colbert and Alexander Kott, Cyber-security of SCADA and other industrial control systems, Springer, 2016.
3. David J.Teumim, Network Security, Second edition, ISA, 2010.
4. Perry S. Marshall and John S. Rinaldi, Industrial Ethernet, Second edition, ISA, 2004.

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MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	2	-	-	-	-
CO2	-	-	3	-	-	-
CO3	-	-	-	-	2	-
CO4	-	-	-	-	-	1
CO5	-	-	-	2	1	-
AVg.	**1**	**2**	**3**	**2**	**1.5**	**1**

Note: 1-low, 2-medium, 3-high, '-"- no correlation

IN3013 ADVANCED MEDICAL INSTRUMENTATION

L	T	P	C
3	0	0	3

UNIT I NTRODUCTION 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 BIOMEDICAL MODELING AND SIMULATION 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 RECORDING TECHNIQUES 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 – Micro fabrication technologies for biomedical Microsystems- microsensors for clinical applications – biomedical microfluid systems.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On successful completion of the course, students will be able to:

- CO1 Explain the principles and concepts of biomedical measurements and instrumentation.
- CO2 Apply fundamental principles for designing and modelling biomedical systems.
- CO3 Analyze biomedical images and signals using mathematical/computational tools.
- CO4 Explain the working principles of diagnostic instruments.
- CO5 Explain the concepts of implants and microdevices.
- CO6 Analyze the safety implications in design of biomedical devices.

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REFERENCES:

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. L.Cromwell, Fred J.Weibell and Erich A.Pfeiffer, “Biomedical Instrumentation and Measurements”, Prentice Hall of India, Digitized 2010.
5. John L.Semmlow, “Biosignal and Biomedical Image Processing”, CRC Press, First Edition, 2004.
6. Joseph J.Carr and John M.Brown, “Introduction to Biomedical Equipment Technology”, Prentice Hall, Fourth Edition, 2004.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	3	-	-
CO2	3	1	2	3	-	-
CO3	3	1	2	3	-	-
CO4	3	1	2	3	-	-
CO5	3	1	2	3	-	-
CO6	3	1	2	3	-	-
AVg.	**3**	**1**	**2**	**3**	**-**	**-**

Note: 1-low, 2-medium, 3-high, ‘-“- no correlation

IN3014 **INSTRUMENTATION STANDARDS** **L T P C**
3 0 0 3

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 Requirements 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 CYBERSECURITY AD SIL STANDARDS 9

Fossil Power Plant Standards - ISA62443, ISA84, IEC61508/61511

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

COURSE OUTCOMES (COs)

On successful completion of the course, students will be able to:

- CO1 Understand the role of standards organization
- CO2 implement different standards related to installation and control system, programming, documentation, equipment in hazardous area and instrument specification forms.
- CO3 utilize standards related to control valve, actuators. orifice sizing, RTD and thermocouple
- CO4 implement standards related to power plant and nuclear power plant.
- CO5 select different standards related to orifice, RTD and thermocouple.
- CO6 Select standards related to programming language.

REFERENCES:

1. API Recommended Practice 551, "Process Measurement Instrumentation", American Petroleum Institute, Washington, D.C., Second Edition, May 2001.
2. API Recommended Practice 554, "Process Instrumentation and Control — 3 parts",

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American Petroleum Institute, Washington, D.C., First 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.
11. BS EN 60584-1, “Thermocouples - EMF specifications and tolerances”, British Standard, 2013.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	-	-	-	1	1
CO2	-	-	-	1	-	1
CO3	-	-	-	-	-	1
CO4	-	-	-	-	-	1
CO5	-	-	-	-	1	1
CO6	-	-	-	-	-	1
AVg.	**-**	**-**	**-**	**1**	**1**	**1**

Note: 1-low, 2-medium, 3-high, ‘-“- no correlation

IN3015 NANOSENSORS AND MEMS

	L	T	P	C
	3	0	0	3

UNIT I INTRODUCTION TO MICRO AND NANOTECHNOLOGY 9

Introduction to miniaturization technology – Comparison of Microstructures and Nanostructures - Micromachining – Materials for MEMS. - Classifications of nanostructured materials – Properties of nanomaterials - Safety aspects.

UNIT II SYNTHESIS OF NANOMATERIALS 9

Bottom up and Top down approaches: Physical vapour deposition – Inert gas condensation, Laser ablation, wire explosion techniques, - Chemical vapour deposition - Self-assembly, - Mechanical milling.

UNIT III FABRICATION TECHNIQUES FOR NANO AND MICRO DEVICES 9

Lithography: Photolithography, – UV lithography, – X-ray lithography, – Electron beam lithography, – Ion beam lithography, - AFM based lithography - STM based lithography - Dip pen lithography – Epitaxy: Molecular Beam Epitaxy, - Atomic Layer Epitaxy

UNIT IV INSTRUMENTATION FOR CHARACTERIZATION 9

X-ray diffraction technique - Scanning Electron Microscopy - Transmission Electron Microscopy – Atomic Force Microscopy – Scanning Tunneling Microscopy – Nano-indentation.

UNIT V MICRO AND NANOSENSING TECHNIQUES 9

MEMS sensors: Pressure sensors, - Mass flow sensors, - Acceleration sensors, - Gas sensors. Nano sensing: Nanowire sensors, - Nanotube sensors, - Nano cantilever sensors, - Nano-biosensors.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On successful completion of the course, students will be able to:

CO1 Explain the principles of nano technology and MEMS.

CO2 Explain and compare the various techniques for synthesis of nano materials for specified applications.

CO3 Compare and analyze the various patterning techniques for development of micro and nano scale devices.

CO4 Select appropriate materials for design of MEMS.

CO5 Explain, compare and select the instrumentation systems for characterization of nano materials.

CO6 Explain and compare various nano sensing and transduction techniques.

REFERENCES:

1 Maluf, N., & Williams, K. (2004). Introduction to microelectromechanical systems engineering. Artech House.

2 Madou, M. (2011). Fundamentals of Microfabrication and Nanotechnology, Vol. 3: From MEMS to Bio-MEMS and Bio-NEMS: Manufacturing Techniques and Applications.

3 Murty, B. S., Shankar, P., Raj, B., Rath, B. B., &Murday, J. (2013). Textbook of nanoscience and nanotechnology. Springer Science & Business Media.

4 Edelstein, A.S., and Cammearata, R.C., eds., "Nano materials: Synthesis, Properties and Applications", Institute of Physics Publishing, Bristol and Philadelphia, 1996.

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5 Gad-el-Hak, M. (Ed.). (2005). MEMS: introduction and fundamentals. CRC press.
6 Bhushan, B. (Ed.). (2010). Springer handbook of nanotechnology. Springer Science & Business Media.
7 Elwenspoek, M., & Wiegerink, R. (2012). Mechanical microsensors. Springer Science & Business Media.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	3	-	-
CO2	3	1	2	3	-	-
CO3	3	1	2	3	-	-
CO4	3	1	2	3	-	-
CO5	3	1	2	3	-	-
CO6	3	1	2	3	-	-
AVg.	**3**	**1**	**2**	**3**	**-**	**-**

Note: 1-low, 2-medium, 3-high, '-"- no correlation

IN3016 INDUSTRIAL SAFETY ENGINEERING **L T P C**
3 0 0 3

UNIT I INTRODUCTION 9

Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

UNIT II FUNDAMENTALS OF MAINTENANCE ENGINEERING 9

Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

UNIT III WEAR AND CORROSION AND THEIR PREVENTION 9

Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods- corrosion monitoring system and PIG detection systems.

UNIT IV FAULT TRACING 9

Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like machine tools, Pumps, Air compressors, Boilers, Electrical motors, - Types of faults in machine tools and their general causes.

UNIT V PERIODIC AND PREVENTIVE MAINTENANCE 9

Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On successful completion of the course, students will be able to:

- CO1 Explain the principles and concepts of maintenance techniques.
- CO2 Explain various accident causation theories, factories act, fire fighting techniques and safety.
- CO3 Analyze the various wear modes in various scenarios.
- CO4 Analyze the various factors influencing corrosion.
- CO5 Select the suitable methods for prevention of wear and corrosion in various scenarios.

CO6 Construct suitable fault tree diagrams for given systems.

REFERENCES:

1. Higgins & Morrow, Maintenance Engineering Handbook, Eighth Edition, 2008.
2. Macdonald, D. (2003). Practical industrial safety, risk assessment and shutdown systems. Elsevier.
3. Deshmukh, L. M. (2005). Industrial Safety Management: Hazard Identification and Risk Control. McGraw-Hill Education.
4. Reese, C. D. (2008). Industrial safety and health for administrative services. CRC Press.
5. Valdez, B., & Schorr, M. (Eds.). (2012). Environmental and industrial corrosion: practical and theoretical aspects. BoD–Books on Demand.
6. Pirro, D.M., Webster, M. and Daschner, E., 2016. Lubrication fundamentals, revised and expanded. CRC Press.
7. Vesely, W. E., Goldberg, F. F., Roberts, N. H., & Haasl, D. F. (1981). Fault tree handbook. Nuclear Regulatory Commission Washington DC.
8. John Cadick, P. E., Capelli-Schellpfeffer, M., Neitzel, D. K., & Winfield, A. (2012). Electrical safety handbook. McGraw-Hill Education.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	3	-	-
CO2	3	1	2	3	-	-
CO3	3	1	2	3	-	-
CO4	3	1	2	3	-	-
CO5	3	1	2	3	-	-
CO6	3	1	1	3	-	-
AVg.	**3**	**1**	**2**	**3**	**-**	**-**

Note: 1-low, 2-medium, 3-high, '-"- no correlation

IN3017 **CLOUD COMPUTING TECHNOLOGIES** **L T P C**
3 0 0 3

UNIT I INTRODUCTION **9**
Introduction- Historical Development – Cloud Computing Architecture – The Cloud Reference Model – Cloud Characteristics –Cloud Deployment Models: Public, Private, Community, Hybrid Clouds- Cloud Delivery Models: IaaS, PaaS, SaaS – Open Source Private Cloud Software: Eucalyptus, Open Nebula, Open Stack.

UNIT II VIRTUALIZATION **9**
Data Center Technology – Virtualization – Characteristics of Virtualized Environments - Taxonomy of Virtualization Techniques – Virtualization and Cloud Computing –Pros and Cons of Virtualization – Implementation Levels of Virtualization – Tools and Mechanisms: Xen, VMWare, Microsoft Hyper-V, KVM, Virtual Box

UNIT III CLOUD COMPUTING MECHANISM **9**
Cloud Infrastructure Mechanism: Cloud Storage, Cloud Usage Monitor, Resource Replication – Specialized Cloud Mechanism: Load Balancer, SLA Monitor, Pay-per-use Monitor, Audit Monitor, Failover System, Hypervisor, Resource Cluster, Multi Device Broker, State Management Database – Cloud Management Mechanism: Remote Administration System, Resource Management System, SLA Management System, Billing Management System

UNIT IV HADOOP AND MAP REDUCE **9**
Apache Hadoop – Hadoop Map Reduce –Hadoop Distributed File System- Hadoop I/O- Developing a MapReduce Application – MapReduce Types and Formats – MapReduce Features– Hadoop Cluster Setup –Administering Hadoop.

UNIT V SECURITY IN THE CLOUD **9**
Basic Terms and Concepts – Threat Agents – Cloud Security Threats –Cloud Security Mechanism: Encryption, Hashing, Digital Signature, Public Key Infrastructure, Identity and Access Management, Single Sign-on, Cloud Based Security Groups, Hardened Virtual Server Images.

TOTAL: 45 PERIODS

COURSE OUTCOMES:
On successful completion of the course, students will be able to:
1. Articulate the main concepts, key technologies, strengths and limitations of cloud computing.
2. Identify the architecture, infrastructure and delivery models of cloud computing.
3. Explain the core issues of cloud computing such as security, privacy and interoperability.
4. Choose the appropriate technologies, algorithms and approaches for the related issues.
5. Facilitate Service Level Agreements (SLA).

REFERENCES:

1. Thomas Erl, Zaigham Mahood, Ricardo Puttini, “Cloud Computing, Concept, Technology &Architecture”, Prentice Hall, 2013.
2. Rajkumar Buyya, Christian Vecchiola, S. Thamarai Selvi, “Mastering Cloud Computing”, TataMcGraw-Hill, 2013.
3. Toby Velte, Anthony Velte, Robert C. Elsenpeter, “Cloud Computing, a PracticalApproach”,Tata McGraw-Hill Edition, 2010.

4. Arshdeep Bahga, Vijay Madisetti, “Cloud Computing: A Hands-On Approach”, UniversitiesPress(India) Private Limited, 2014.
5. Tom White, “Hadoop: The Definitive Guide”, O’Reilly Media, 4th Edition, 2015.
6. James E Smith and Ravi Nair, “Virtual Machines”, Elsevier, 2005.
7. John Rittinghouse& James Ransome, “Cloud Computing, Implementation, Management andStrategy”, CRC Press, 2010.

MAPPING OF COs WITH POs

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

Note: 1-low, 2-medium, 3-high, ‘-“- no correlation

IN3018 ROBOTICS FOR INDUSTRIAL AUTOMATION

	L	T	P	C
	3	0	0	3

UNIT I INTRODUCTION TO SERIAL MANIPULATORS 9

Types of Industrial Robots, Definitions – Classifications Based on Work Envelope – Generations Configurations and Control Loops - Co-Ordinate System – Need for Robot – Basic Parts and Functions – Specifications – Robotic Sensor - Position and Proximity's Sensing – Tactile Sensing –Sensing Joint Forces.

UNIT II MECHANICAL DESIGN OF ROBOT SYSTEM 11

Robot Motion – Linkages and Joints – Mechanism – Method for Location and Orientation of Objects - Kinematics of Robot Motion – Direct and Indirect Kinematics Homogeneous Transformations – D-H Transformation – Drive Systems – End Effectors – Types, Selection, Classification and Design of Grippers — Gripper Force Analysis.

UNIT III ROBOT PROGRAMMING & ROBOTIC WORK CELLS 9

Types of Programming – Teach Pendant Programming – Basic Concepts in AI Techniques – Concept of Knowledge Representations – Expert System and its Components Robotic Cell Layouts – Inter Locks.

UNIT IV MOBILE ROBOTICS 8

Wheeled Robot and Legged Robot – Architecture - Configurations and Stability - Design Space and Mobility Issues - Teleportation and Control – Localization – Navigation - AGV

UNIT V APPLICATIONS OF ROBOTS 8

Robotic Surgery - Manufacturing Industries - Material Handling, Assembly, Inspection - Space – Underwater – Nuclear industry – Humanoid Robots.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On successful completion of the course, students will be able to:

CO1: Classify the various configurations of serial manipulators.
CO2: Develop the kinematics solution of serial manipulator.
CO3: Find the differences of robot programing languages and safety consideration of industrial manipulator.
CO4: Develop the legged and wheeled mobile robots.
CO5: Demonstrate the robots in various applications.

REFERENCES:

1. Fu.K.S, Gonzalac R.C, Lee C.S.G, "Robotics Control, Sensing, Vision and Intelligence", Mc- GrawHill book co 2011.
2. Groover.M.P. "Industrial Robotics, Technology, Programming and Application", Mc-Graw Hill bookand co. 2012.
3. John J Craig, "Introduction to Robotics", Pearson, 2005.
4. Saeed B.Niku, "Introduction to Robotics, Analyses, Systems, Applications", Prentice Hall Pvt Ltd.,2005.
5. Yoram Koren, "Robotics", McGraw Hill 2006.

MAPPING OF COs WITH POs

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

Note: 1-low, 2-medium, 3-high, '-"- no correlation

IN3019 ELECTROMECHANICAL SYSTEM DESIGN

L	T	P	C
3	0	0	3

UNIT I ELEMENTS OF MECHATRONICS 8

Electromechanical systems - Identification of Electromechanical Systems - Requirements in Real World Problems -– Key Elements — Identification of Key Elements in Various Systems - Application Overview – System Design Process - Recent Advancements in Electromechanical Systems for Modern Automation.

UNIT II MODELLING & SYSTEM IDENTIFICATION 9

Need for Modelling – Systems Overview – Representation of Systems in State Space – Analogue Approach – Parametric and Non-Parametric Modelling - Bond Graph Approach for Modelling of Electrical, Mechanical, Thermal, Fluid and Hybrid Systems – System Identification – White, Grey and Block Box Modelling - Overview – Types - Least Square Method.

UNIT III SIMULATION 8

Simulation Fundamentals – Simulation Life Cycle – Monte Carlo Simulation – Solution for Model Equations and their Interpretations – Hardware-In-Loop Simulation (HIL) - Controller Prototyping – Software's for Simulation and Integration.

UNIT IV DESIGN OPTIMIZATION 9

Optimization – Problem Formulation - Constraints – Overview of Linear and Nonlinear Programming Techniques – Other Optimization Techniques - Optimal Design of Electromechanical Systems with Case Studies.

UNIT V CASE STUDIES ON MODELING 11

Modelling and Simulation of Automotive System - Power Window, Engine Timing, Building Clutch Look-Up, Antilock Braking System and Automatic Transmission Controller — Modelling of Manufacturing Systems, Inspection System, Transportation System, Industrial Manipulator, Light Motor Vehicle, Aerial Vehicle, Underwater Vehicle.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On successful completion of the course, students will be able to:

CO1: Identify the list of elements required integrate the entire mechatronic systems developments.

CO2: Model the system dynamics of hybrid systems and to trial the system identification techniques and to practice the design, integration and simulation in virtual systems that arecloser to the real time systems' functionalities and its parameters.

CO3: Follow standard simulation procedure for algorithm and controller development.

CO4: Use the optimization concepts mechatronics elements selection and process parameter optimization.

CO5**:** Integrate and analyze the mechatronics system design virtually and able to fine tune the system design and control algorithms in the software-in-loops before real time development.

Attested

REFERENCES

1. Bradley, D. Dawson, N.C.Burd and A.J. Loader, “Mechatronics: Electronics in Product andProcess”, Chapman and Hall, London, 1999.
2. Bolton, “Mechatronics – Electronic Control Systems in Mechanical and Electrical Engineering”,Addison Wesley Longman Ltd., 2009.
3. Brian Morriss, “Automated Manufacturing Systems — Actuators Controls, Sensors andRobotics”, McGraw Hill International Edition, 2000.
4. Devadas Shetty, Richard A.Kolkm, “Mechatronics System Design”, PWS Publishing Company,2009.
5. Ogata.K, “Modern Controls Engineering“, Prentice Hall of India Pvt. Ltd., 2005.

MAPPING OF COs WITH POs

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

Note: 1-low, 2-medium, 3-high, ‘-“- no correlation