DEPARTMENT OF INSTRUMENTATION ENGINEERING

Vision of the Department

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

Mission of the Department

- Provide the students with strong foundation in Electronics, Instrumentation and Control Engineering.
- Enhance the core competency of the students to cater to the needs of the industries and research 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 educational programs.
- Carry out interdisciplinary research and consultancy in the cutting-edge technology.

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M.E INSTRUMENTATION ENGINEERING

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

Master of Instrumentation Engineering curriculum is designed to prepare the graduates to acquire knowledge, skills and attitudes in order to:

1. Excel in their preferred profession in government and private sectors.
2. 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.
3. 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.
4. Promote new ideas, innovation solutions and alternative methods in their work places contributing to the development of entrepreneurship.
5. Adhere to professional ethics and exhibit leadership and inter-personal skills in their workplace.

PROGRAMME OUTCOMES (POs):

The graduates will have

1. An ability to independently carry out research and developmental work and arrive at well founded solutions for complex Instrumentation Engineering problems.
2. An ability to communicate efficiently the engineering facts with a wide range of engineering community and others, to understand and prepare reports and design documents; to make effective presentation and to frame and follow instructions.
3. Ability to analyze complex problems in Instrumentation domain and recommend right solutions with acquired mastery technical knowledge in Instrumentation Engineering.
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.

PROGRAM SPECIFIC OUTCOMES (PSOs):

After completion of Instrumentation Engineering program, students be able to gain core competency skills in domains such as Instrumentation and Process control.

1. Students will be able to design, develop and validate models for sensors, actuators, and industrial processes.
2. Students will be able to design, develop, and implement control schemes for various industrial processes.
3. Students will be able to configure Industrial Automation Systems such as PLC and DCS and there by achieve centralized monitoring and decentralized control of industrial processes.

PEO/ PO/PSO Mapping:

PEO/PO/PSO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
PEO 1	S	M	S	M	M	M	S	S	M
PEO 2	M	S	S	M	L	S	M	S	M
PEO 3	S	S	S	S	L	M	M	M	S
PEO 4	L	M	S	S	S	M	L	M	M
PEO 5	L	L	L	M	S	M	M	M	M

PEO/PO/PSO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
	M	M	S	M	M	M	M	M	M

MAPPING OF COURSE OUTCOMES AND PROGRAMME OUTCOMES

	Course Name	PO 01	PO 02	PO 03	PO 04	PO 05	PO 06	PSO 01	PSO 02	PSO 03
SEM I	**THEORY**									
	Numerical Methods and Optimization Techniques	M	-	-	M	-	L	-	M	-
	Transducers and Smart Instruments	L	L	S	S	L	L	S	L	S
	Advanced Instrumentation Systems	L	L	L	S	M	L	S	S	S
	Advanced Digital Signal Processing	S	M	L	M	-	L	-	M	M
	Process Control: Design and Analysis	S	L	S	L	S	-	-	S	-
	Research Methodology and IPR	S	S	-	-	S	S	-	M	-
	Audit Course – I									
	PRACTICALS									
	Process Control and Instrumentation Laboratory	S	L	L	S	S			S	L
	Embedded System Laboratory	S	-	S	S	-	-	S	S	-
SEM II	**THEORY**									
	Advanced Process Control	S	-	S	M	-	L	-	S	-
	Instrumentation System Design	-	-	S	S	S	-	-	S	S
	Applied Machine Learning	M	L	S	M	L	L	L	L	L
	Audit Course –II									
	PRACTICALS									
	Industrial Automation Laboratory	S	L	S	M	M	M	M	M	S
	Advanced Process Control Laboratory	S	M	S	L	L	S	S	S	M
	Mini Project with Seminar									
SEM III	**THEORY**									
	Open Elective									
	PRACTICALS									
	Project Phase I	M	M	M	M	M	M	M	M	M
SEM IV	**PRACTICALS**									
	Project Phase II	S	S	S	M	M	M	M	M	M
ELECTIVES	**THEORY**									
	State and Parameter Estimation	S	M	S	M	M	L	L	M	-
	Linear and Nonlinear systems theory	S	M	M	S	L	M	L	S	L

	Industrial Data Communication	S	M	M	S	-	M	-	-	-
	Process Data Analytics	S	M	M	S	-	M	-	-	-
	Optimal Control	M	M	S	M	-	M	-	-	-
	Adaptive Control	L	-	S	M	-	-	-	M	-
	Robust Control	L	-	S	M	-	-	-	M	-
	Fault Detection and Diagnosis	M	-	S	-	-	L	M	M	-
	Industrial Drives and Control	M	L	M	M	-	-	M	L	-
	Advanced Image Processing	M	-	M	S	-	M	-	-	-
	Industrial Internet of Things	M	S		M	M	L	-	-	-
	Safety Instrumented Systems	L	L	M	M	-	-	-	-	-
	Instrumentation Standards	-	-	-	S	S	S	S	-	S
	Cyber Physical Systems	S	M	-	S	S	M	-	-	-
	Cyber Security for Industrial Automation	S	M	-	M	S	S	-	-	-
	Industrial Robotics	✓	✓	✓	✓	✓	✓			
	Mechatronics System Design	✓	✓	✓	✓	✓	✓			
	Drives and Actuators for Automation	✓	✓	✓	✓	✓				
	Flight Instrumentation	✓	✓	✓	✓	✓				
	Aerospace Guidance and Control	✓	✓	✓	✓	✓				
	CMOS Analog IC Design	✓	✓	✓	✓	✓				
	Automotive Electrical and Electronics	✓	✓	✓	✓	✓				
	Cloud Computing Technologies	✓		✓	✓		✓			
	Big Data Mining and Analytics	✓		✓	✓		✓			

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M.E INSTRUMENTATION ENGINEERING
CURRICULA AND SYLLABI FOR I - IV SEMESTERS

SEMESTER I

S. NO.	CODE NO.	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MA5103	Numerical Methods and Optimization Techniques	FC	3	1	0	4	4
2.	IN5101	Transducers and Smart Instruments	PCC	3	0	0	3	3
3.	IN5102	Advanced Instrumentation Systems	PCC	3	0	0	3	3
4.	IN5103	Advanced Digital Signal Processing	PCC	3	0	0	3	3
5.	IN5104	Process Control: Design and Analysis	PCC	3	0	0	3	3
6.	RM5151	Research Methodology and IPR	RMC	2	0	0	2	2
7.		Audit Course – I *	AC	2	0	0	2	0
PRACTICALS								
8.	IN5111	Process Control and Instrumentation Laboratory	PCC	0	0	4	4	2
9.	IN5112	Embedded System Laboratory	PCC	0	0	6	6	3
			TOTAL	**19**	**1**	**10**	**30**	23

*Audit Course is optional

SEMESTER II

S. NO.	CODE NO.	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	IN5201	Advanced Process Control	PCC	3	0	0	3	3
2.	IN5202	Instrumentation System Design	PCC	3	0	0	3	3
3.	IN5203	Applied Machine Learning	PCC	3	0	0	3	3
4.		Program Elective II	PEC	3	0	0	3	3
5.		Program Elective III	PEC	3	0	0	3	3
6.		Audit Course –II*	AC	2	0	0	2	0
PRACTICALS								
7.	IN5211	Industrial Automation Laboratory	PCC	0	0	6	6	3
8.	IN5212	Advanced Process Control Laboratory	PCC	0	0	4	4	2
9.	IN5213	Mini Project with Seminar	EEC	0	0	4	4	2
			TOTAL	**17**	**0**	**14**	**31**	**22**

*Audit Course is optional

SEMESTER III

S. NO.	CODE NO.	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.		Program Elective IV	PEC	3	0	0	3	3
2.		Program Elective V	PEC	3	0	0	3	3
3.		Open Elective (one from list of 6 courses)	OEC	3	0	0	3	3
PRACTICALS								
4.	IN5311	Project Phase I	EEC	0	0	12	12	6
			TOTAL	**9**	**0**	**12**	**21**	**15**

SEMESTER IV

S. NO.	CODE NO.	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICALS								
1.	IN5411	Project Phase II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL CREDITS TO BE EARNED FOR THE AWARD OF THE DEGREE = 72

FOUNDATION COURSES (FC)

S. No.	Code No.	Course Title	Periods per week			Credits	Semester
			Lecture	Tutorial	Practical		
1.	MA5103	Numerical Methods and Optimization Techniques	3	1	0	4	1

PROFESSIONAL CORE COURSES (PCC)

S. NO.	CODE NO.	COURSE TITLE	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS	SEMESTER
			L	T	P			
1.	IN5101	Transducers and Smart Instruments	3	0	0	3	3	1
2.	IN5102	Advanced Instrumentation Systems	3	0	0	3	3	1
3.	IN5103	Advanced Digital Signal Processing	3	0	0	3	3	1
4.	IN5104	Process Control: Design and Analysis	3	0	0	3	3	1
5.	IN5111	Process Control Laboratory	0	0	4	4	2	1
6.	IN5112	Embedded system Laboratory	0	0	6	6	3	1
7.	IN5201	Advanced Process Control	3	0	0	3	3	2
8.	IN5202	Instrumentation System Design	3	0	0	3	3	2
9.	IN5203	Applied Machine Learning	3	0	0	3	3	2
10.	IN5211	Industrial Automation Laboratory	0	0	6	6	3	2
11.	IN5212	Advanced Process Control Laboratory	0	0	4	4	2	2

PROFESSIONAL ELECTIVE COURSE (PEC)

S. NO.	CODE NO.	COURSE TITLE	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
			L	T	P		
1.	IN5001	State And Parameter Estimation	3	0	0	3	3
2.	IN5002	Linear and Nonlinear Systems Theory	3	0	0	3	3
3.	IN5003	Industrial Data Communication	3	0	0	3	3

4.	IN5004	Process Data Analytics	3	0	0	3	3
5.	IN5005	Optimal Control	3	0	0	3	3
6.	IN5006	Adaptive Control	3	0	0	3	3
7.	IN5007	Robust Control	3	0	0	3	3
8.	IN5008	Fault Detection and Diagnosis	3	0	0	3	3
9.	IN5009	Industrial Drives and Control	3	0	0	3	3
10.	IN5010	Advanced Image Processing	3	0	0	3	3
11.	IN5011	Industrial Internet of Things	3	0	0	3	3
12.	IN5012	Safety Instrumented Systems	3	0	0	3	3
13.	IN5013	Instrumentation Standards	3	0	0	3	3
14.	IN5014	Cyber Physical Systems	3	0	0	3	3
15.	IN5015	Cyber Security for Industrial Automation	3	0	0	3	3
16.	MR5071	Industrial Robotics	3	0	0	3	3
17.	MR5251	Mechatronics System Design	3	0	2	5	4
18.	MR5151	Drives and Actuators for Automation	3	0	2	5	4
19.	AV5151	Flight Instrumentation	3	0	0	3	3
20.	AV5251	Aerospace Guidance and Control	3	1	0	4	4
21.	VE5251	CMOS Analog IC Design	3	0	0	3	3
22.	AM5071	Automotive Electrical and Electronics	3	0	0	3	3
23.	CP5073	Cloud Computing Technologies	3	0	2	5	4
24.	BD5151	Big Data Mining and Analytics	3	0	0	3	3

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. NO.	CODE NO.	COURSE TITLE	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS	SEMESTER
			L	T	P			
1.	IN5213	Mini Project with Seminar	0	0	4	4	2	2
2.	IN5311	Project Phase I	0	0	12	12	6	3
3.	IN5411	Project Phase II	0	0	24	24	12	4

RESEARCH METHODOLOGY AND IPR COURSES (RMC)

S. NO.	CODE NO.	COURSE TITLE	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS	SEMESTER
			L	T	P			
1.	RM5151	Research Methodology and IPR	2	0	0	2	2	1

OPEN ELECTIVE COURSES [OEC]

*(Out of 6 Courses one Course must be selected)

S.NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	OE5091	Business Data Analytics	3	0	0	3	3
2.	OE5092	Industrial Safety	3	0	0	3	3
3.	OE5093	Operations Research	3	0	0	3	3
4.	OE5094	Cost Management of Engineering Projects	3	0	0	3	3
5.	OE5095	Composite Materials	3	0	0	3	3
6.	OE5096	Waste to Energy	3	0	0	3	3

AUDIT COURSES (AC)

Registration for any of these courses is optional to students

SL. NO	COURSE CODE	COURSETITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	AX5091	English for Research Paper Writing	2	0	0	0	1/2
2.	AX5092	Disaster Management	2	0	0	0	
3.	AX5093	Sanskrit for Technical Knowledge	2	0	0	0	
4.	AX5094	Value Education	2	0	0	0	
5.	AX5095	Constitution of India	2	0	0	0	
6.	AX5096	Pedagogy Studies	2	0	0	0	
7.	AX5097	Stress Management by Yoga	2	0	0	0	
8.	AX5098	Personality Development Through Life Enlightenment Skills	2	0	0	0	
9.	AX5099	Unnat Bharat Abhiyan	2	0	0	0	
Total Credits						**0**	

SUMMARY

S.No	NAME OF THE PROGRAMME					
	SUBJECT AREA	CREDITS PER SEMESTER				TOTAL CREDITS
		I	II	III	IV	
1.	FC	4	0	0	0	04
2.	PCC	17	14	0	0	31
3.	PEC	0	6	6	0	12
4.	RMC	2	0	0	0	02
5.	OEC	0	0	3	0	03
6.	EEC		2	6	12	20
7.	Non Credit/Audit Course	✓	✓	0	0	0
						72

MA5103 NUMERICAL METHODS AND OPTIMIZATION TECHNIQUES

L	T	P	C
3	1	0	4

COURSE OBJECTIVES

- To make the students understand the methods to numerically solve the set of simultaneous ordinary differential equations.
- To make the students understand the methods to numerically solve the partial differential equations.
- To make the students understand the finite element methods for solving the PDEs.
- To get exposed to the ideas of obtaining the most optimal solution for a problem with given constraints.
- To teach the students to decompose the optimization problem into subspaces and hence solve recursively.

UNIT I ORDINARY DIFFERENTIAL EQUATIONS 12

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

UNIT II FINITE DIFFERENCE 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

COURSE OUTCOMES

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

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

REFERENCE BOOKS

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, 2015.
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, Ne Delhi, 2017.

MAPPING COURSE OUTCOMES WITH PROGRAMME OUTCOMES

CO/PO/PSO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
CO101.1	M			M				M	
CO101.2	M			M				M	
CO101.3	M			M				M	
CO101.4	M			M		L		M	
CO101.5				M		L		M	

Mapping Numerical Methods and Optimization Techniques with POs and PSOs

CO/PO/PSO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
	M	-	-	M	-	L	-	M	-

IN5101	TRANSDUCERS AND SMART INSTRUMENTS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To impart knowledge on transducer characteristics.
- To make the students understand the importance of error analysis and to determine the uncertainties associated with measuring instruments.
- To make the students understand the importance of smart sensor technologies and familiarization of standards for smart sensor Interface
- To provide exposure to manufacturing techniques and different types of Micro sensors and actuators
- To provide an overview of latest advancement and trends in transducers and smart instruments.

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, ADC, Accuracy and Dynamic range - Universal Sensor Interface –converters - front end circuits. DAQ – Design - Digital conversion techniques - Microcontrollers and digital signal processors for smart sensors – selection - Timer, Analog comparator, ADC and DAC modules – Remote calibration – Smart Transducer Interface standard (IEEE 1451)- Interfacing Resistive and Inductive sensors to microcontrollers without ADC– Smart transmitters:- HART, FF and Profibus.

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.

TOTAL : 45 PERIODS

COURSE OUTCOMES

1. Ability to categorize and characterize a conventional transducer
2. Ability to analyze and quantify the uncertainties in measurement data
3. Ability to design smart sensors with special features.
4. Acquire a comprehensive Knowledge of manufacturing techniques and design aspects of micro sensors and actuators
5. Keep abreast of latest sensor technology and advanced measurement methodologies
6. Ability to suggest a proper transducer for an application

REFERENCE BOOKS

1 Ernest O Doebelin and Dhanesh N Manik, “Measurement Systems Application and Design”, 6th Edition, Tata Mc-Graw Hill, 2011.

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

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

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

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

MAPPING COURSE OUTCOMES WITH PROGRAMME OUTCOMES

CO/PO/PSO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
CO102.1	M	L	S	S	M	L	S	M	S
CO102.2	S	S	S	L	L	L	S	S	M
CO102.3	M	L	S	S	L	L	S	L	S
CO102.4	L	L	S	S	L	M	S	L	M
CO102.5	L	L	S	L	L	S	M	M	S
CO102.6	L	L	L	L	L	L	**M**	L	L

Mapping Transducers and Smart Instruments with POs and PSOs

CO/PO/PSO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
	L	L	S	S	L	L	S	L	S

IN5102	ADVANCED INSTRUMENTATION SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To provide knowledge on measurement techniques, selection, application and calibration of temperature and pressure sensors.
- To make students understand the construction, working principle, application, selection and calibration of various transducers used for the measurement of flow and level.
- To make students aware of the various available methods of chemical analysis of a given chemical sample with specific emphasis on spectroscopy, chromatography, electrochemical analysis and mass spectrometry.
- To make the students aware of basic concepts of safety instrumented system and familiarize with Instrumentation standards.
- To make students familiarize with Instrumentation Symbols, Abbreviations and Identification for Instruments ,Process Flow diagrams, Instrument Loop diagrams, Instrument Hookup diagrams and Piping and Instrumentation Diagrams

UNIT I MEASUREMENT OF PROCESS PARAMETERS – 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 **9**

FLOW

Variable head flow meters – positive displacement flow meters-variable area flow meters-Electrical type flow meters – Open channel flow measurement –Solid flow measurement.

LEVEL

Float gauges – Displacer type – Bubbler system – Load cell – Conductivity sensors – Capacitive sensors – D/P methods – 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.

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 (COs)

1. Ability to understand the construction, working and calibration of temperature, pressure, flow and level sensors.
2. Ability to understand the working principle of different chemical analyzers.
3. Ability to select instruments for specific application.
4. Ability to understand the role of Safety instrumented system and instrumentation standards in the industry.
5. Ability to analyze process hazards and apply risk assessment techniques for an industrial plant.
6. 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.

TEXT BOOKS:

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

REFERENCE BOOKS:

1. 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

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-Informative6 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.

2. 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.

3. 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 COURSE OUTCOMES WITH PROGRAMME OUTCOMES

CO/PO/PSO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
CO103.1	S	L	L	L	L	L	L	L	S
CO103.2	S	L	L	L	L	L	L	L	S
CO103.3	L	S	L	L	M	M	S	S	L
CO103.4	L	S	L	S	L	L	S	S	L
CO103.5	L	L	S	L	M	L	L	L	S
CO103.6	L	L	S	S	L	L	S	S	L

Mapping Advanced Instrumentation Systems with POs and PSOs

CO/PO/PSO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
	L	L	L	S	M	L	S	S	S

IN5103	ADVANCED DIGITAL SIGNAL PROCESSING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To provide a comprehensive review of digital signals, systems and filters.
- To provide the foundation for signal modeling, linear prediction and estimation theory.
- To impart knowledge on adaptive filter design, multi-rate signal processing and filter banks.

UNIT I REVIEW OF DIGITAL SIGNALS, SYSTEMS AND FILTERS 9

Discrete Time Fourier Transform – 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 Multirate 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

1. Ability to apply the knowledge of mathematics, science, and engineering for the analysis and design of digital systems
2. Ability to identify, formulate and solve engineering problems in the area of random signal processing and spectrum estimation.
3. Ability to estimate the states of the stochastic system using Kalman filter.
4. Ability to design adaptive filters using recursive algorithms with realistic constraints.
5. Analyze multirate systems and filter banks
6. Ability to select the analysis tools and design algorithms for the implementation of adaptive

systems.

TEXT BOOKS:

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, "Multirate Systems and Filter Banks", Prentice Hall Signal Processing Series, Impearson, 2008

REFERENCE BOOKS

1. Tulay Adali and Simon Haykin, "Adaptive Signal Processing, Next Generation Solutions", John Wiley and Sons, 2010.
2. Monson Hayes, "Digital Signal Processing", 2nd edition, McGraw Hill, 2011.
3. Ali Ahammad Shoukat Choudhury, Sirish L. Shah and Nina F.Thornhill, "Diagnosis of Process Nonlinearities and Valve Stiction: Data Driven Approaches", Springer, 2008.
4. NPTEL Video Lecture series on, "Advanced Digital Signal Processing" by Prof. V.M. Gadre, IIT Bombay.

MAPPING COURSE OUTCOMES WITH PROGRAMME OUTCOMES

CO/PO/PSO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO 3
CO104.1	S								M
CO104.2	S	S						S	
CO104.3	S	M							
CO104.4	S			M					M
CO104.5	S								
CO104.6			L			L		M	

Mapping Advanced Digital Signal Processing with POs and PSOs

CO/PO/PSO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
	S	M	L	M	-	L	-	M	M

IN5104	PROCESS CONTROL: DESIGN AND ANALYSIS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To introduce the technical terms associated with Process Control domain and impart the knowledge on mathematical modeling of processes
- To provide an overview of the features associated with Industrial Type PID Controller such as reset windup, bumpless auto-manual transfer, proportional kick and derivative kick.
- To make the students understand the various PID tuning methods
- To elaborate different types of control schemes such as cascade control, feed-forward control, DMC, GPC, Inferential control schemes, Multi-variable control schemes etc.

UNIT I PROCESS DYNAMICS **9**

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

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

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

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

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

Cascade control – Split-range - Feed-forward control – Ratio control – Inferential control — override control - Smith predictor control scheme - Internal Model Controller - IMC PID controller –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

1. Ability to Apply knowledge of mathematics, science, and engineering to the build and

analyze models for flow, level, and thermal processes

2. Ability to determine the advanced features supported by the Industrial Type PID Controller.
3. Ability to design, tune and implement SISO P/PI/PID Controllers to achieve desired Performance for various processes
4. Ability to analyze Multivariable Systems and Design Multi-variable and Multi-loop Control Schemes for various processes namely four-tank system, pH process, bio-reactor, distillation column
5. Ability to Identify, formulate, and solve problems in the process control domain
6. Ability to analyze various advanced control schemes and recommend the right control strategy for a given application in accordance with the industrial requirement.

REFERENCE BOOKS

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

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

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

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

MAPPING COURSE OUTCOMES WITH PROGRAMME OUTCOMES

CO/PO/PSO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
CO105.1	S	L		L				S	
CO105.2	S	S		L				S	
CO105.3	S		S	S	S			S	
CO105.4	S		S	L	S			S	
CO105.5	S			L	S			S	
CO105.6	S			S				S	

Mapping Process Control: Design And Analysis with POs and PSOs

CO/PO/PSO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
	S	L	S	L	S	-	-	S	-

RM5151 RESEARCH METHODOLOGY AND IPR LT P C
2 0 0 2

COURSE OBJECTIVES:

To impart knowledge and skills required for research and IPR:

- Problem formulation, analysis and solutions.
- Technical paper writing / presentation without violating professional ethics
- Patent drafting and filing patents.

UNIT I RESEARCH PROBLEM FORMULATION 6

Meaning of research problem- Sources of research problem, criteria characteristics of a good research problem, errors in selecting a research problem, scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, necessary instrumentations

UNIT II LITERATURE REVIEW 6

Effective literature studies approaches, analysis, plagiarism, and research ethics.

UNIT III TECHNICAL WRITING /PRESENTATION 6

Effective technical writing, how to write report, paper, developing a research proposal, format of research proposal, a presentation and assessment by a review committee.

UNIT IV INTRODUCTION TO INTELLECTUAL PROPERTY RIGHTS (IPR) 6

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

UNIT V INTELLECTUAL PROPERTY RIGHTS (IPR) 6

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System, IPR of Biological Systems, Computer Software etc.

Traditional knowledge Case Studies, IPR and IITs.

TOTAL: 30 PERIODS

COURCE OUTCOMES:

1. Ability to formulate research problem
2. Ability to carry out research analysis
3. Ability to follow research ethics
4. Ability to understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
5. Ability to understand about IPR and filing patents in R & D.

REFERENCES:

1. Asimov, "Introduction to Design", Prentice Hall, 1962.
2. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
3. Mayall, "Industrial Design", McGraw Hill, 1992.
4. Niebel, "Product Design", McGraw Hill, 1974.
5. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners" 2010

MAPPING COURSE OUTCOMES WITH PROGRAMME OUTCOMES

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO106.1	S	S						M	
CO106.2	S							M	
CO106.3	S							M	
CO106.4	S				S			M	
CO106.5	S					S		M	

Mapping Research Methodology and IPR with POs and PSOs

CO/PO/PSO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
	S	S	-	-	S	S	-	M	-

IN5111	PROCESS CONTROL AND INSTRUMENTATION LABORATORY	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES

To impart theoretical and practical skills in

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

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 a Typical Industrial Process.
7. Design and Implementation of Feed forward and Cascade control schemes on the simulated model of a Typical Industrial Process.
8. (a) Analysis of MIMO system.
   (b) Design and implementation of Multi-loop PID and Multivariable PID control schemes on the simulated model of a Typical Industrial Process.
9. Control of flow process using industrial type PID controller.
10. PC based control of Level process.
11. Design and implementation of Gain scheduled Adaptive controller on the simulated model of a variable area tank process.
12. Design and implementation of a Fuzzy Logic Control scheme on the simulated model of a Typical Industrial Process.

TOTAL : 60 PERIODS

COURSE OUTCOMES

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. Be able to 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. Ability to obtain servo and regulatory responses and be able to analyze and draw meaningful conclusions.

6. Be able to design and implement Feed-forward, cascade control scheme, simple adaptive control scheme, model based control scheme and fuzzy logic control scheme.

MAPPING COURSE OUTCOMES WITH PROGRAMME OUTCOMES

CO/PO/PSO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
CO107.1	S	L	L	L	L			S	L
CO107.2	S	S		S				S	L
CO107.3	S	L		S				S	L
CO107.4	S		S	L	S			S	L
CO107.5	S		L	L	S			S	L
CO107.6	S		L	S	L			S	L

Mapping Process Control Laboratory with POs and PSOs

CO/PO/PSO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
	S	L	L	S	S			S	L

IN5112	EMBEDDED SYSTEM LABORATORY	L	T	P	C
		0	0	6	3

COURSE OBJECTIVES

- To introduce the architectural features and associated peripherals of embedded system.
- To impart knowledge on Embedded C-programming.
- To provide an insight over the practical aspects of interfacing field devices with microcontroller.
- To facilitate the students to realize the significant features of real time embedded system.
- To enable the students to utilize the power of IOT for embedded applications.

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

Experiment(s)
- Interfacing limit switch using hardware interrupts.
- Design of a programmable Timer.

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.

Assignment(s)
- Design of a multichannel data acquisition system.
- 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 appropriate serial communication protocols

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

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
- To enable the students to carry out IoT enabled data acquisition

Demonstration
- 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.

TOTAL : 90 PERIODS

COURSE OUTCOMES

1. Ability to realize the functions of various constitutional modules of an embedded system.
2. Ability to formulate suitable strategies for interfacing real world sensors and actuators with microcontrollers.
3. Ability to recognize the operational behavior of RTOS based systems and use them efficiently in design environments.
4. Ability to identify, formulate and apply embedded control strategies for industrial applications.
5. Ability to infer the concept of IoT and demonstrate its power in real world applications.
6. Ability to devise design strategies for industrial embedded applications.

MAPPING COURSE OUTCOMES WITH PROGRAMME OUTCOMES

CO/PO	**PO01**	**PO02**	**PO03**	**PO04**	**PO05**	**PO06**	**PSO1**	**PSO2**	**PSO3**
CO108.1			S						
CO108.2	M		S	S					
CO108.3			S						
CO108.4	S		S	S			S	S	
CO108.5			S	S					
CO108.6	S		S				S	S	

Mapping Embedded System Lab with POs and PSOs

CO/PO/PSO	**PO01**	**PO02**	**PO03**	**PO04**	**PO05**	**PO06**	**PSO1**	**PSO2**	**PSO3**
	S	-	S	S	-	-	S	S	-

IN5201	ADVANCED PROCESS CONTROL	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

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

UNIT I CONTROL OF TIME-VARYING AND NONLINEAR SYSTEMS 9

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

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 H_2 Controller Design - H-Infinity Controller Design –– Effects of Weighting Functions in H-Infinity Control.

UNIT V FAULT DIAGNOSIS AND FAULT-TOLERANT CONTROL 9

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

TOTAL : 45 PERIODS

COURSE OUTCOMES

1. Ability to apply knowledge of mathematics, science, and engineering to build and analyze models for time-varying systems and non-linear systems.
2. Ability to design and implement adaptive controllers such as gain-scheduled adaptive controller, Model-reference adaptive controller and Self-tuning controller
3. Ability to Identify, formulate, and solve optimal controller

4. Ability to Analyze Fractional-order systems, Fractional-order- controller and Design controller for fractional order systems
5. Ability to design and implement H_2 and H-infinity Controllers
6. Ability to use the FDI Techniques, such as Principal component Analysis, state observer to detect and diagnose faults in sensors and actuators

REFERENCE BOOKS

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

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

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

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

MAPPING COURSE OUTCOMES WITH PROGRAMME OUTCOMES

CO/PO/PSO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
CO201.1	S		S	M		L		S	
CO201.2	S		S	M				S	
CO201.3	S		S	M				S	
CO201.4	S		S	M				S	
CO201.5	S		S	M				S	
CO201.6	S		S	M				S	

Mapping Advanced Process Control with POs and PSOs

CO/PO/PSO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
	S	-	S	M	-	L	-	S	-

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

COURSE OBJECTIVES

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

UNIT I DESIGN OF SIGNAL CONDITIONING CIRCUITS 9

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

UNIT II DESIGN OF TRANSMITTERS 9

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 – 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: - Liquid, Gas and steam services – Control valve sizing – Liquid, Gas and steam Services and Standards.

TOTAL : 45 PERIODS

COURSE OUTCOMES

1. Competence to design signal conditioning circuits for temperature sensors, V/I and I/V converters
2. Ability to design, fabricate and test smart transmitters
3. Ability to design, fabricate and test PID controllers.
4. Ability to carry out orifice and control valve sizing for Liquid/Steam Services
5. Exposure to simulation tools such as MATLAB.
6. Capability to 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.

5 Thakore and Bhatt ,”Introduction to Process Engineering and Design” , TATA McGraw-

Hill,2007.

MAPPING COURSE OUTCOMES WITH PROGRAMME OUTCOMES

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
CO202.1			S					S	
CO202.2			S	S	S				S
CO202.3									
CO202.4				S	S			S	
CO202.5				S	S				
CO202.6				S	S			S	

Mapping Instrumentation system design with POs and PSOs

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
	-	-	S	S	S	-	-	S	S

IN5203	APPLIED MACHINE LEARNING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To provide an introduction to several fundamental concepts and methods for machine learning.
- To teach machine learning algorithms and their applications.
- To provide the knowledge related to processing, analyzing and handling data sets.
- To illustrate the typical applications of various clustering based learning algorithms
- To impart knowledge on bayesian based learning algorithms.

UNIT I INTRODUCTION TO MACHINE LEARNING 9

Objectives of machine learning – Human learning/ Machine learning – Types of Machine learning:- Supervised Learning, Unsupervised learning, Reinforcement Learning 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

1. Ability to understand the basic theory underlying machine learning.
2. Ability to understand a range of machine learning algorithms along with their strengths & weaknesses and able to select appropriate ML algorithm.
3. Ability to formulate machine learning problems corresponding to different applications.
4. Ability to apply machine learning algorithms to solve problems of moderate complexity.
5. Ability to read and understand the work reported in the research papers in the area of machine learning.
6. Gain capacity to select suitable software tools, understand and develop codes for machine learning algorithms to solve moderately complex problems.

REFERENCE BOOKS

1 Stephen Marsland, Machine Learning: An Algorithmic Perspective

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 COURSE OUTCOMES WITH PROGRAMME OUTCOMES

CO/PO/PSO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
CO203.1	M	L	S	M	L	L	L	L	L
CO203.2	S	L	S	S	L	L	S	S	L
CO203.3	S	L	S	S	S	M	S	S	M
CO203.4	S	M	S	M	L	M	S	S	S
CO203.5	S	S	S	S	L	M	M	M	M
CO203.6	S	M	S	S	L	L	M	S	M

Mapping Applied Machine Learning with Pos and PSOs

CO/PO/PSO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
	M	L	S	M	L	L	L	L	L

IN5211	INDUSTRIAL AUTOMATION LABORATORY	L	T	P	C
		0	0	6	3

COURSE OBJECTIVES

- To impart knowledge on architecture of PLC and DCS.
- To introduce students on how to program using all five IEC-61131-3 programming languages.
- To introduce students on how to interface Field devices (Conventional/Smart) with PLC and DCS.
- To make the students configure the IoT gateway

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.
2. Interfacing Limit switches and a Pump 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 of tags 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 18.1 Standard) 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.

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 a DCS.
2. How to interface Limit Switches, Pumps 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

Practical Module – 11 Interfacing Wireless (Wireless HART) 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

1. Ability to understand all the important components such as PLC, SCADA, DCS, I/O modules and field devices of an industrial automation system.
2. Ability to develop PLC program in different languages for industrial applications.
3. Gain hands on experience in interfacing transmitters and final control elements with PLC and DCS.
4. Be able to Configure and develop Feedback Control Schemes using PLC and DCS.
5. Able to select and use most appropriate automation technologies for a given application.
6. Able to configure IoT gateway for any industrial process using DCS.
7. Able to interface smart filed devices(HART /FF enabled field devices)with DCS and gain knowledge on the recent developments in industrial data networks.

MAPPING COURSE OUTCOMES WITH PROGRAMME OUTCOMES

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
CO204.1	S	M	S	M	M	M	M	M	S
CO204.2	S	M	S	S	M	M	M	M	S
CO204.3	S	L	S	M	M	M	S	M	S
CO204.4	S	L	S	M	M	M	M	S	S
CO204.5	S	L	S	M	S	S	S	M	S
CO204.6	S	L	M	S	M	S	M	M	S
CO204.7	S	L	S	S	M	M	S		S

Mapping Industrial Automation Laboratory with Pos and PSOs

CO/PO/PSO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
	S	L	S	M	M	M	M	M	S

IN5212	ADVANCED PROCESS CONTROL LABORATORY	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES

To impart Theoretical and Practical Skills on

- Linear/Non-Linear Process Identification
- State and Parameter Estimation
- Fractional Order PID / Robust PID Controller
- Design of Soft – Sensors
- Dynamic Matrix Control / Optimal Control Scheme

List of Experiments

1. Identification and validation of Linear Dynamic model (Black Box) of a Process using Non-Parametric Methods.

2. Identification and validation of Linear Dynamic model (Black Box) of a Process using 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 Transfer Function model of a Process.

8. Design and Implementation of a Robust-PID Controller on the Transfer Function model of a Process.

9. Design and Implementation of Model Reference Adaptive Controller on the simulated model of a variable area tank process.

10. Design and Implementation of Dynamic Matrix Control Scheme on the simulated model of a Temperature Process.

11. Design and Implementation Optimal Control Schemes (Fuel/Energy/Time) on the simulated model of a system.

12. Identification of a Non-Linear Dynamic model (Black Box) of a Process using Machine Learning Algorithms

TOTAL : 60 PERIODS

COURSE OUTCOMES

1. Ability to identify parametric and non-parametric models for linear systems
2. Ability to estimate model parameters and state variables using suitable algorithms

3. Ability to develop soft sensors using multivariate statistical methods.
4. Ability to design advanced control schemes such as Robust, Adaptive, Optimal and Fractional order
5. Ability to identify non-linear models using Machine learning Algorithms.
6. Ability to recommend a suitable control scheme for given application

.

MAPPING COURSE OUTCOMES WITH PROGRAMME OUTCOMES

CO/PO/PSO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
CO205.1	S	L	S	L	L	S	S	S	M
CO205.2	S	M	S	L	L	S	S	S	M
CO205.3	S	M	S	L	L	S	S	S	M
CO205.4	S	M	S	L	L	S	S	S	M
CO205.5	S	L	S	S	L	S	S	S	M
CO205.6	S	L	S	L	L	S	S	S	M

Mapping Advanced Process Control Laboratory with Pos and PSOs

CO/PO/PSO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
	S	M	S	L	L	S	S	S	M

IN5001	STATE AND PARAMETER ESTIMATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

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

UNIT I KALMAN UPDATE BASED FILTERS & PARTICLE FILTER 9

Review of Matrix Algebra and Matrix Calculus and Probability Theory – Least Square Estimation – 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

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

REFERENCE BOOKS

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

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

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

4 W.T.Miller, R.S.Sutton and P.J.Webrose, "Neural Networks for Control", MIT Press, 1996.

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 COURSE OUTCOMES WITH PROGRAMME OUTCOMES

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
CO001.1	S	M	S	M			L	M	
CO001.2	M	M	S	M			L		
CO001.3	S	S	S	M				M	
CO001.4	S		S	M					
CO001.5			S	L				M	
CO001.6	S		S	M	M	L			

Mapping State and Parameter Estimation with POs and PSOs

CO/PO/PSO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
	S	M	S	M	M	L	L	M	-

IN5002	LINEAR AND NONLINEAR SYSTEMS THEORY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

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

UNIT I STATE SPACE APPROACH **9**

Review of state model for systems – 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 ESTIMATOR **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 – Krasovskil's method – Variable Gradient Method – Popov's Stability Criterion – Circle Criterion

UNIT V NON-LINEAR SYSTEMS ANALYSIS **9**

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

TOTAL : 45 PERIODS

COURSE OUTCOMES

1. Ability to represent the time-invariant systems in state space form as well as analyze, Whether the system is stabilizable, controllable, observable and detectable.
2. Ability to design state feedback controller and state observers
3. Ability to classify singular points and construct phase trajectory using delta and isocline methods.
4. Ability 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.
5. Ability to describe non-linear behaviors such as Limit cycles, input multiplicity and output multiplicity, Bifurcation and Chaos.
6. Ability to identify the different types of non-linearity existing in the system.

REFERENCE BOOKS

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

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

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

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

MAPPING COURSE OUTCOMES WITH PROGRAMME OUTCOMES

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
CO002.1	S	S	M	S	L	M	S	S	L
CO002.2	S	S	M	S	L	M	L	S	L
CO002.3	S	M	M	S	L	M	L	S	L
CO002.4	S	M	M	S	L	M	L	S	L
CO002.5	M	M	M	S	L	L	L	S	L
CO002.6	M	M	M	M	L	L	L	M	L

Mapping Linear and Non-Linear system Theory with POs and PSOs

CO/PO/PSO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
	S	M	M	S	L	M	L	S	L

IN5003	INDUSTRIAL DATA COMMUNICATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

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

UNIT I DATA NETWORK FUNDAMENTALS 9

ISO/OSI Reference model - TCP/IP Protocol Stack- EIA 232 interface standard – EIA 485 interface standard - Media access protocol: Command/response, CSMA/CD — IEEE 802.3 Ethernet standard Bridges –Routers – TCP/IP - 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 AS – INTERFACE (AS-i), DEVICENET AND INDUSTRIAL ETHERNET 9

AS interface: Introduction – Physical layer – Data link layer – Operating characteristics.
Devicenet: Introduction – Physical layer – Data link layer and Application layer.
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 – ISA100 – Introduction to Industrial IOT.

TOTAL : 45 PERIODS

COURSE OUTCOMES(COs)

After completing the course, the students will gain ability to

1. Differentiate various types of industrial data network standards and the associated protocols based on their specifications and applications.
2. Analyze the various characteristics of each layer of the protocol stack pertaining to different Industrial data network standards
3. Compare the performance of the standards and infer the advantages and drawbacks of each for a given industrial application
4. Select and use the most appropriate networking technologies and standards for a given application.
5. Identify procedures for fault-free operations in the data communications links
6. Infer the requirements of an industry and select a wired or wireless solution for installing Industrial data network

REFERENCE BOOKS:

1 Bowden,R., “HART Application Guide”, HART Communication Foundation, 1999.

2 Berge,J., “Field Buses for Process Control: Engineering, Operation, and Maintenance”, ISA Press, 2004.

3 Lawrence (Larry) M. Thompson and Tim Shaw, “Industrial Data Communications”, 5th Edition ,ISA Press, 2015.

4 NPTEL Lecture notes on," Computer Networks" by Department of Electrical Engg, IIT Kharagpur.
5 Mackay, S., Wright,E., Reynders,D., and Park,J., "Practical Industrial Data Networks: Design, Installation and Troubleshooting", Newnes Publication, 1st edition, Elsevier, 2004.
6 Buchanan,W., "Computer Busses: Design and Application", CRC Press, 2000.
7 Bela G.Liptak, "Instrument Engineers' Handbook, Volume 3 : Process Software and Digital Networks", 4th Edition, CRC Press, 2011.

MAPPING COURSE OUTCOMES WITH PROGRAMME OUTCOMES

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
CO003.1	M			M					
CO003.2		S	S	S		M			
CO003.3	S	M		S		L			
CO003.4	S	M	M	S		L			
CO003.5	M			S					
CO003.6	M								

Mapping Industrial Data Communication with POs and PSOs

CO/PO/PSO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
	S	M	M	S	-	M	-	-	-

IN5004	PROCESS DATA ANALYTICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

To introduce students the basic concepts of

- Experimental Design
- Linear Regression Analysis
- Linear Model Selection and Regularization
- Classification
- Process Identification, Performance Monitoring and Soft Sensor Design.

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 studies on 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 Cross Validation – 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 and boosting -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 (COs)

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

REFERENCE BOOKS:

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 COURSE OUTCOMES WITH PROGRAMME OUTCOMES

CO/PO/PSOs	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
CO004.1				M					
CO004.2		S	S	S		M			
CO004.3	S	M				L			
CO004.4	M	M	M	S		L			
CO004.5				S					
CO004.6				L					

Mapping Process Data Analytics with POs and PSOs

CO/PO/PSO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
	S	M	M	S	-	M	-	-	-

IN5005	OPTIMAL CONTROL	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To provide an exposure to different type of optimal control problems such as time-optimal, fuel optimal, energy optimal control problems
- To impart knowledge and skills needed to design Linear Quadratic Regulator for Time-invariant and Time-varying Linear system (Continuous time and Discrete-time systems)
- To introduce concepts needed to design optimal controller using Dynamic Programming Approach and H-J-B equation.
- To provide an exposure to various types of fault tolerant control schemes such as Passive and active approaches
- To introduce concepts needed to design optimal controller in the presence of state constraints and time optimal controller

UNIT I CALCULUS OF VARIATIONS AND OPTIMAL CONTROL 9

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

UNIT II LINEAR QUADRATIC OPTIMAL CONTROL SYSTEM 9

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

UNIT III DISCRETE TIME OPTIMAL CONTROL SYSTEMS 9

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

UNIT IV PONTRYAGIN MINIMUM PRINCIPLE 9

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

UNIT V CONSTRAINED OPTIMAL CONTROL SYSTEMS 9

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

TOTAL : 45 PERIODS

COURSE OUTCOMES

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

REFERENCE BOOKS

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

MAPPING COURSE OUTCOMES WITH PROGRAMME OUTCOMES

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
CO005.1	S		S						
CO005.2		M	S	M		M			
CO005.3	M		M			L			
CO005.4	M	M	M			L			
CO005.5									
CO005.6									

Mapping Optimal Control with POs and PSOs

CO/PO/PSO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
	M	M	S	M	-	M	-	-	-

IN5006	ADAPTIVE CONTROL	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To impart knowledge on how to recursively estimate the parameters of discrete input – output models using recursive parameter estimation methods
- To make the student understand the principles of STR, MRAC and Gain scheduling.
- To make the student design simple adaptive controllers for linear systems using STR, MRAC and Gain scheduling

UNIT I INTRODUCTION **9**

Introduction - Adaptive Schemes - The adaptive Control Problem – Applications-Parameter estimation:-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

1. Ability to understand and apply the estimation algorithm to estimate the parameters of the process.
2. Ability to understand the basic concepts to master the techniques of adaptive control.
3. Ability to use appropriate software tools for design of adaptive controllers and analysis of the process.
4. Ability to identify, formulate, analyze engineering problems and carry out research by designing suitable adaptive schemes for complex instrumentation problem.
5. Ability to apply the concepts to design adaptive control for multidisciplinary problem.
6. Ability to make use of the techniques for self and lifelong learning to keep in pace with the new technology.

REFERENCE BOOKS

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

MAPPING COURSE OUTCOMES WITH PROGRAMME OUTCOMES

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
CO006.1	L		M	M					
CO006.2			M	S					
CO006.3			S					M	
CO006.4	L		S						
CO006.5			S					M	
CO006.6			S					M	

Mapping Adaptive Control with POs and PSOs

CO/PO/PSO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
	L	-	S	M	-	-	-	M	-

IN5007	ROBUST CONTROL	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To review the properties of linear systems in terms of robust stability and performance
- To introduce the skills required to formulate Robust Control Problem based on Robust stability and Robust performance
- To develop the skills needed to design H_2 optimal controller to achieve the desired performance
- To develop the skills needed to design H-infinity sub-optimal controllers by means of Riccati equations
- To develop the skills needed to design H-infinity sub-optimal controllers by means of LMI Approach

UNIT I INTRODUCTION **9**

Introduction – Norms of vectors and Matrices – Norms of Systems – Calculation of operator Norms – Specification for feedback systems – Co-prime factorization and Inner functions

UNIT II H_2 OPTIMAL CONTROL **9**

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

UNIT III H-INFINITY OPTIMAL CONTROL-RICCATI APPROACH **9**

Formulation – Characterization of H-infinity sub-optimal controllers by means of Riccati equations – H-infinity control with full information – Mixed Sensitivity design

UNIT IV H-INFINITY OPTIMAL CONTROL- LMI APPROACH **9**

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

UNIT V SYNTHESIS OF ROBUST CONTROLLERS & CASE STUDIES **9**

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

TOTAL : 45 PERIODS

COURSE OUTCOMES

1. Ability to define and enumerate properties of linear systems in terms of robust stability and performance
2. Ability to formulate Robust Control Problem based on Robust stability and Robust performance.
3. Ability to design H_2 optimal controller to achieve the desired performance
4. Ability to design H-infinity sub-optimal controllers by means of Riccati equations
5. Ability to design H-infinity sub-optimal controllers by means of LMI approach
6. Ability to design Robust controller by means of synthesis approach.

REFERENCE BOOKS

1 U. Mackenroth “Robust Control Systems: Theory and Case Studies”, Springer International Edition, 2010.

2 D. Xue, Y.Q. Chen, D. P. Atherton, "Linear Feedback Control Analysis and Design with MATLAB, Advances In Design and Control”, Society for Industrial and Applied Mathematics, 2007.

3 I. R. Petersen, V.A. Ugrinovskii and A. V. Savkin, “Robust Control Design using H-infinity Methods”, Springer, 2000.
4. M. J. Grimble, “Robust Industrial Control Systems: Optimal Design Approach for Polynomial Systems”, John Wiley and Sons Ltd., Publication, 2006.

MAPPING COURSE OUTCOMES WITH PROGRAMME OUTCOMES

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
CO007.1			M	M					
CO007.2			M	S					
CO007.3			S					M	
CO007.4	L		S					M	
CO007.5	L		S					M	
CO007.6	L		S					M	

Mapping Robust Control with POs and PSOs

CO/PO/PSO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
	L	-	S	M	-	-	-	M	-

IN5008	FAULT DETECTION AND DIAGNOSIS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To give an overview of different Fault Detection and Diagnosis methods.
- To present an overview of various types of fault detection schemes using Limit Checking, Parameter estimation methods, Principle Component Analysis.
- To impart knowledge and skills needed to design and detect sensor and actuators faults using structured residual approach as well as directional structured residual approach.
- To impart knowledge and skills needed design and detect faults in sensor and actuators using GLR and MLR based Approaches.
- To impart knowledge and skills needed to detect and quantify and compensate stiction in Control valves.

UNIT I INTRODUCTION & ANALYTICAL REDUNDANCY CONCEPTS 9

Introduction – Types of faults and different tasks of Fault Diagnosis and Implementation – Different approaches to FDD: Model free and Model based approaches-Introduction-Mathematical representation of Faults and Disturbances: Additive and Multiplicative types – 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 (COs)

1. Ability to explain different approaches to Fault Detection and Diagnosis.
2. Ability detect faults using Limit Checking, Parameter estimation methods, Principle Component Analysis.
3. Ability to design and detect sensor and actuators faults using structured residual approach as well as directional structured residual approach.
4. Ability to design and detect faults in sensor and actuators using GLR and MLR based Approaches.
5. Ability to detect and quantify and compensate stiction in Control valves.
6. Ability to take up industrial problem, detect and diagnose the fault.

TEXT BOOKS

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

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

REFERENCE BOOKS

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

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

3. Blanke, Mogens; Kinnaert, Michel; Lunze, Jan; Staroswiecki, Marcel ,"Diagnosis and Fault-Tolerant Control", Springer, 2015.

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

MAPPING COURSE OUTCOMES WITH PROGRAMME OUTCOMES

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
CO008.1	M		M			L	M		
CO008.2			M				M	M	
CO008.3			S				M		
CO008.4			S				S		
CO008.5			M						
CO008.6			M			L		M	

Mapping Fault Detection & Diagnosis with POs and PSOs

CO/PO/PSO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
	M	-	S	-	-	L	M	M	-

IN5009	INDUSTRIAL DRIVES AND CONTROL	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

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

UNIT I INTRODUCTION TO ELECTRIC DRIVES **9**

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

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

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

UNIT III CONTROL OF DC DRIVES **9**

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

UNIT IV CONTROL OF AC DRIVES **9**

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

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

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

TOTAL : 45 PERIODS

COURSE OUTCOMES

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

REFERENCE BOOKS

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

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

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

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

MAPPING COURSE OUTCOMES WITH PROGRAMME OUTCOMES

CO/PO/PSO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
CO009.1	M	M	M					L	
CO009.2			L	M			M		
CO009.3		L	M	L			M	L	
CO009.4		L	L	M				L	
CO009.5		L	M				L		
CO009.6			L				L		

Mapping Industrial Drives and Control with POs and PSOs

CO/PO/PSO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
	M	L	M	M	-	-	M	L	-

IN5010 **ADVANCED IMAGE PROCESSING** **L T P C**
3 0 0 3

COURSE OBJECTIVES

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

UNIT I 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

1. Ability to understand the technical terms associated with image and video processing.
2. Ability to select the appropriate preprocessing techniques for manipulation of images
3. Ability to utilize the different approaches of image enhancement, segmentation and analysis techniques
4. Ability to apply image processing techniques in both the spatial and frequency domains.
5. Ability to use appropriate software tools(Example: Matlab, Open CV and Python) for image and video processing
6. Ability to apply the imaging techniques to various applications.

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 COURSE OUTCOMES WITH PROGRAMME OUTCOMES

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
CO010.1	M								
CO010.2	M		M						
CO010.3			M	S					
CO010.4									
CO010.5				S					
CO010.6						M			

Mapping Applied Image Processing with POs and PSOs

CO/PO/PSO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
	M	-	M	S	-	M	-	-	-

IN5011	INDUSTRIAL INTERNET of THINGS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

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

UNIT I INTERNET PRINCIPLES **9**

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

UNIT II PHYSICAL AND LOGICAL DESIGN METHODOLOGIES **9**

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

UNIT III PROTOCOLS AND CLOUDS FOR IOT **9**

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

UNIT IV INDUSTRIAL IOT AND SECURITY **9**

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

UNIT V PROCESS DATA ANALYTICS **9**

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

TOTAL : 45 PERIODS

COURSE OUTCOMES:

1. Apply the knowledge of Internet principles and protocols to understand the architecture and specifications of a given network
2. Design simple IoT applications using prototyping boards
3. Select the appropriate protocol for a specific network implementation
4. Identify the security level needed for a particular industrial IOT application
5. Analyze the process data using cloud based process data management tools
6. Acquire insight regarding the technological challenges and opportunities in Industrial IoT design and implementation

REFERENCE BOOKS

1 ArshdeepBahga and Vijay Madisetti, “Internet of Things A Hands-on Approach”, Universities Press (India), 2015

2 Alasdair Gilchrist," Industry 4.0:The Industrial Internet of Things”, Apress, 2016.

3 Adrian McEwen and Hakim Cassimally, “Designing the Internet of Things”, John Wiley & Sons, 2014

4 Francis Dacosta, “Rethinking the Internet of Things”, Apress Open, 2014.
5 Beheshti**,** S.-M.-R., Benatallah**,** B., Sakr**,** S., Grigori, D., Motahari-Nezhad**,** H.R., Barukh**,** M.C., Gater, A., Ryu, S.H."Process Analytics Concepts and Techniques for Querying and Analyzing Process Data" Springer International Publishing Switzerland,2016.

MAPPING COURSE OUTCOMES WITH PROGRAMME OUTCOMES

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
CO011.1	M								
CO011.2	M	S		M	M				
CO011.3				M	M				
CO011.4				M	M				
CO011.5		S							
CO011.6						L			

Mapping Industrial Internet of Things with POs and PSOs

CO/PO/PSO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
	M	S		M	M	L	-	-	-

IN5012	SAFETY INSTRUMENTED SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To make the students aware of basic concepts of safety instrumented system, standards and risk analysis techniques.
- To make the students understand different layers of protection.
- To make students conscious about safety instrumentation applications.

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 (COs)

1. Ability to understand Non-SIS layers of protection and the need for SIS in process industries.
2. Ability to state the associated SIS standards.
3. Ability to implement hazard analysis & risk assessment to identify process hazards & risks.
4. Ability to determine the target SIL & safety requirements specifications
5. Ability to develop detailed SIS design, installation & operation.
6. Ability to implement SIS analysis & design for a furnace/ fired heater system.

TEXT BOOKS:

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", exida2nd Edition 2016.

REFERENCE BOOKS:

1. William M. Goble and Harry Cheddie, "Safety Instrumented Systems Verification: Practical Probabilistic Calculations" ISA, 2005.

2. Edward Marszal, Eric W. Scharpf, "Safety Integrity Level Selection: Systematic Methods Including Layer of Protection Analysis", ISA, 2002.

3. 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 COURSE OUTCOMES WITH PROGRAMME OUTCOMES

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
CO012.1									
CO012.2	L								
CO012.3			M	M					
CO012.4				M					
CO012.5		L	M						
CO012.6			M						

Mapping Safety Instrumented System with POs and PSOs

CO/PO/PSO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
	L	L	M	M	-	-	-	-	-

IN5013	INSTRUMENTATION STANDARDS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

To impart basic knowledge on Instrumentation standards, principles and its behavior.

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 II ISA STANDARDS - CONTROL VALVE AND ACTUATOR 9

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

UNIT IV ISA STANDARDS - FOSSIL AND NUCLEAR POWER PLANTS 9

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

UNIT V BS , ISO, IEC, & ANSI 9

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

TOTAL : 45 PERIODS

COURSE OUTCOMES (COs)

1. Understand the role of standards organization
2. Ability to implement different standards related to installation and control system, programming, documentation, equipments in hazardous area and instrument specification forms.
3. Skill to utilise standards related to control valve, actuators. orifice sizing, RTD and thermocouple
4. Capability to implement standards related to power plant and nuclear power plant.
5. Ability to select different standards related to orifice ,RTD and thermocouple.
6. Select standards related to programming language.

TEXT BOOKS:

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”, 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 COURSE OUTCOMES WITH PROGRAMME OUTCOMES

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
CO013.1					S	S			
CO013.2				S		S			
CO013.3						S	S		
CO013.4						S			S
CO013.5					S	S			
CO013.6				S		S			S

Mapping Instrumentation Standards with POs and PSOs

CO/PO/PSO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
	-	-	-	S	S	S	S	-	S

IN5014	CYBER PHYSICAL SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To understand the nature of continuous and discrete systems
- To develop synchronous and asynchronous model of processes
- To specify both safety and liveness requirements in temporal logic and to debug the correctness of the protocol using model checking
- To develop and analyse model of timed and hybrid systems

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

TEXT BOOKS:

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-Physical Systems Approach, Lulu.com, First Edition, Jan 2013.

REFERENCE BOOKS:

1. Sang C.Suh , U.John Tanik and John N.Carbone , Applied Cyber-Physical systems, Springer,2014

MAPPING COURSE OUTCOMES WITH PROGRAMME OUTCOMES

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
CO014.1	S	M							
CO014.2					S				
CO014.3						M			
CO014.4									
CO014.5					M				
CO014.6				S					

Mapping Cyber Physical Systems with POs and PSOs

CO/PO/PSO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
	S	M	-	S	S	M	-	-	-

IN5015 CYBER SECURITY FOR INDUSTRIAL AUTOMATION L T P C

3 0 0 3

COURSE OBJECTIVES

- To understand the Industrial security environment and cyber attacks
- To analyze and assess risks in the industrial environment
- To access, design and implement cyber security
- To test and troubleshoot the industrial network security system

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:

1. Ability to apply basis of science and engineering to understand Industrial security environment and cyberattacks.
2. Ability to analyze and assess risks in the industrial environment
3. Ability to access the cybersecurity of IACS
4. Ability to design and implement cybersecurity
5. Ability to test and troubleshoot the industrial network security system

TEXT BOOKS:.

1. Ronald L and Krutz, Industrial Automation and Control System Security Principles,ISA, 2016.

REFERENCE BOOKS:

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

MAPPING COURSE OUTCOMES WITH PROGRAMME OUTCOMES

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
CO015.1	S	M							
CO015.2									
CO015.3					M				
CO015.4						S			
CO015.5					S				
CO015.6				M					

Mapping Cyber Security for Industrial Automation with POs and PSOs

CO/PO/PSO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
	S	M	-	M	S	S	-	-	-

MR5071 INDUSTRIAL ROBOTICS

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

- To know the basic terminologies, classification of robot and configurations of serial manipulator.
- To understand the mechanical design and kinematics of serial manipulator.
- To learn the robot programing and safety consideration of industrial manipulator.
- To understand the concepts and stabilization of legged and wheeled mobile robots.
- To demonstrate the robots in various applications.

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

Upon completion of this course, the 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.

COURSE OUT COMES COs	Programme Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
1	Ě										Ě	Ě
2		Ě	Ě	Ě							Ě	Ě
3	Ě	Ě	Ě	Ě	Ě	Ě					Ě	Ě
4	Ě	Ě	Ě	Ě	Ě	Ě					Ě	Ě
5	Ě	Ě	Ě	Ě	Ě	Ě					Ě	Ě

REFERENCES:

1. Fu.K.S, Gonzalac R.C, Lee C.S.G, “Robotics Control, Sensing, Vision and Intelligence”, Mc- Graw Hill book co 2011.
2. Groover.M.P. “Industrial Robotics, Technology, Programming and Application”, Mc-Graw Hill book and 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.

MR5251 MECHATRONICS SYSTEM DESIGN

L	T	P	C
3	0	2	4

COURSE OBJECTIVES

- To enlist the various elements required to design and integrate the mechatronic systems.
- To acquire the Modelling skill to capture the system dynamics of hybrid systems and to familiar the system identification techniques and to practice the design and assembly of mechanical system in software environment for integrating various system sub-elements.
- To familiar the standard simulation procedure for algorithm and controller development and to practice simulate and verify interactions and functions of integrated systems and its elements for fine tuning the design and control for real time system development.
- To apply the optimization procedure for the appropriate selection of mechatronic system elements and process parameter optimization.
- To understand, apply, analyze and evaluate the functions of systems models for integrating the virtual elements of mechatronics.

UNIT I ELEMENTS OF MECHATRONICS 8

Comparison of Conventional System vs. Mechatronic System – Identification of Mechatronic System Requirements in Real World Problems - Mechatronics System Overview – Key Elements – Identification of Key Elements in Various Systems - Application Overview – Mechatronics System Design Process - Recent Advancements in Mechatronics System 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 Mechatronics System with Case Studies.

UNIT V CASE STUDIES ON MODELING OF MECHATRONIC SYSTEMS 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.

LECTURE: 45 PERIODS

COURSE OUTCOMES

Upon completion of this course, the 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 are closer 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.

COURSE OUT COMES Cos	Programme Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
1	Ě										Ě	Ě
2	Ě	Ě	Ě	Ě	Ě	Ě					Ě	Ě
3		Ě	Ě	Ě	Ě	Ě					Ě	Ě
4			Ě	Ě	Ě						Ě	Ě
5	Ě	Ě	Ě	Ě	Ě	Ě					Ě	Ě

REFERENCES

1. Bradley, D. Dawson, N.C.Burd and A.J. Loader, "Mechatronics: Electronics in Product and Process", 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 and Robotics", 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.

LABORATORY

LIST OF EXPERIMENTS

1. Modelling and Simulation of Vehicle and its Automotive Sub System.
2. Modelling and Simulation of 6 DOF Serial Manipulators.
3. Modelling and Simulation of Parallel Manipulator.
4. Modelling and Simulation of Aerial Vehicle.
5. Modelling and Simulation of Mobile Robot.

PRACTICAL: 30 PERIODS
TOTAL: 75 PERIODS

MR5151 DRIVES AND ACTUATORS FOR AUTOMATION

L	T	P	C
3	0	2	4

COURSE OBJECTIVES

- To recognize the standard symbols and to understand the functions of basic fluid power generation and actuation elements.
- To realize the functions of fluid regulation and control elements and its typical uses in fluid power circuit and to acquire the practice on assembling the various types of pneumatic circuits.
- To familiar and exercise the design procedure of various types of pneumatic and hydraulic fluid power circuits and to provide a training to create the various types of hydraulic circuits.
- To understand the typical functions and selections of various types electrical actuators and to provide the hands on training to the use of various electrical motors for automatic control.
- To apprehend the utilities of mechanical and power electronic drives for various functional requirements of actuators and control valves.

UNIT I FLUID POWER SYSTEM GENERATION AND ACTUATORS 9

Need For Automation, Classification of Drives - Hydraulic, Pneumatic and Electric –Comparison – ISO Symbols for their Elements, Selection Criteria. Generating Elements**-** Hydraulic Pumps and Motor Gears, Vane, Piston Pumps – Motors - Selection and Specification - Drive Characteristics – Utilizing Elements - Linear Actuator – Types, Mounting Details, Cushioning – Power Packs – Accumulators.

UNIT II CONTROL AND REGULATIING ELEMENTS 8

Control and Regulating Elements — Direction, Flow and Pressure Control Valves -Methods of Actuation, Types, Sizing of Ports. Spool Valves - Operating Characteristics -Electro Hydraulic Servo Valves - Types - Characteristics and Performance.

UNIT III CIRCUIT DESIGN FOR HYDRAULIC AND PNEUMATICS 10

Typical Design Methods – Sequencing Circuits Design - Combinational Logic Circuit Design - Cascade Method – KV Mapping - Electrical Control of Pneumatic and Hydraulic Circuits - Use of Relays, Timers, Counters, Programmable Logic Control of Hydraulics - Pneumatics Circuits - PLC Ladder Programming

UNIT IV ELECTRICAL ACTUATORS 9

DC Motors – Construction, Working Principle, Classification, Characteristics, Applications – Single Phase and Three Phase AC Motors – Construction, Working Principle, Classification, Characteristics and Applications, Special Electrical Motors - Servomotors - Stepper Motors, Principle, Classification, Construction and Working - BLDC Motor and its Operating Modes - Piezo Electric Actuators – Linear Electrical Actuators - Hybrid Actuators.

UNIT V ELECTRICAL DRIVE CIRCUITS 9

Drives for Motion Control - DC Motors - Speed, Torque, Direction and Position Control - H-Bridge under PWM Mode**.** Control of AC Motor Drives – VFD Drives – Energy Saving AC Drives - AC Servo Drives - Speed, Breaking, Direction, Position and Torque Control – Stepper Motor Drive Circuits for Speed and Position Control - Drives for BLDC Motor - Selection of Drives – Protection and Switchgears.

LECTURE = 45 PERIODS

COURSE OUTCOMES

Upon completion of this course, the students will be able to:

CO1: Use the appropriate fluid power generation and actuation elements and fluid power symbols to design and integrate the pneumatic and hydraulic systems.

CO2: Select and design the basic fluid power circuits using control valves and regulating elements for various types' of actuation and breaking**.**

CO3: Analyze and design the complex sequences of cylinders using advanced techniques for manual and automatic control.

CO4: Identify and select the appropriate electrical actuators for typical applications of system development.

CO5: Analyze the need of appropriate drive and its functions for various actuator and valve control in mechatronic system development.

COURSE OUT COMES COs	Programme Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
1	Ě										Ě	Ě
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4		Ě	Ě	Ě	Ě	Ě					Ě	Ě
5	Ě	Ě	Ě	Ě	Ě	Ě					Ě	Ě

REFERENCES

1. Antony Esposito, "Fluid Power Systems and Control", Prentice-Hall, 2006.
2. Austin Hughes, "Electric Motors and Drives Fundamentals, Types and Applications", Fourth Edition, Elsevier, 2013
3. Gopal K.Dubey, "Fundamentals of Electrical Drives", Narosa Publications, 2001.
4. Peter Rohner, "Fluid Power Logic Circuit Design", the Macmillan Press Ltd., London, 1979.
5. Singh.M.D, Khanchandani.K.B, "Power Electronics", Second Edition, McGraw-Hill, 2008.

LABORATORY

LIST OF EXPERIMENTS

FLUID POWER DRIVES

1. Experimental Verification of Speed Control Circuits in Pneumatic and Hydraulic Trainer.
2. Experimental Verification of Single and Double Acting Cylinder Circuits Using Different Directional Control Values.
3. Experimental Verification of Electro-Pneumatic Circuits.
4. Experimental Verification of Pneumatic Sequencing Circuits.
5. Experimental Verification of Logic, Metre-in and Metre-out Pneumatic Circuits.
6. Experimental Verification of Electro Pneumatic Sequencing Circuits.
7. Experiments on Control of PLC Based Electro Pneumatic Sequencing Circuits.
8. Experiments on Control of PLC Based Electro Hydraulic Sequencing Circuits.

ELECTRICAL DRIVES

1. Experiments on Position, Speed and Direction Control of AC and DC Motors.
2. Experiments on Position, Speed and Direction Control of Stepper Motor.
3. Experiments on Various Types of Switching and Protection Devices.

PRACTICAL = 30 PERIODS

TOTAL = 75 PERIODS

AV5151	FLIGHT INSTRUMENTATION	LT P C 3 0 0 3

OBJECTIVES:

- To learn the concept of measurement, error estimation and classification of aircraft instrumentation and displays
- To study air data instruments and synchronous data transmissions systems
- To study gyroscope and its purposes, aircraft compass system and flight management system
- To study Data acquisition and handling systems
- To impart knowledge about the basic and advanced flight instruments, their construction, characteristics and their operation.

UNIT I MEASUREMENT SCIENCE AND DISPLAYS 9

Instrumentation brief review-Concept of measurement - Functional elements of an instrument system –Transducers - classification - classification of aircraft instruments-Instrument displays panels and cockpit layout, Electronic Flight Instrument System.

UNIT II AIR DATA INSTRUMENTS AND SYNCHRO TRANSMISSION SYSTEMS 9

Air data instruments-airspeed, altitude, Vertical speed indicators, Altitude alerting systems, Machmeter, Mach Warning system, Static Air temperature, Angle of attack measurement, Stall Warning system, Synchronous data transmission system

UNIT III GYROSCOPIC AND ADVANCED FLIGHT INSTRUMENTS 9

Gyroscope and its properties, gyro system, Gyro horizon, Erection systems for Gyro Horizons-Direction gyro-direction indicator, Rate gyro-rate of turn and slip indicator, Turn coordinator, acceleration and turning errors, Standby Attitude Director Indicator, Gyro stabilized Direction Indicating Systems, Advanced Direction Indicators, Horizontal Situation Indicator.

UNIT IV AIRCRAFT COMPASS SYSTEMS & FLIGHT MANAGEMENT SYSTEM 9

Direct reading compass, magnetic heading reference system-detector element, monitored gyroscope system, DGU, RMI, deviation compensator. FMS- Flight planning-flight path optimization-operational modes-4D flight management

UNIT V POWER PLANT INSTRUMENTS & FLIGHT DATA RECORDING 9

Pressure measurement, temperature measurement, fuel quantity measurement, engine power and control instruments-measurement of RPM, manifold pressure, torque, exhaust gas temperature, EPR, Engine Fuel Indicators, engine vibration monitoring, Cockpit Voice Recorder and Flight Data Recorder.

TOTAL: 45 PERIODS

OUTCOMES:

Students will be able to:

CO1: Design the error model and estimate the error in the aircraft instruments
CO2: Explain about the various air data systems and synchronous data transmissions systems
CO3: Apply the principle of gyroscope, DGU, RMI, FMS in 4D flight management in the Avionics

domain requirements.

CO4: Classify the different sensors and select the appropriate one for the given requirements.

CO5: Explain the operation and importance of engine instruments and flight data recorder.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓		✓								
CO2	✓						✓					
CO3					✓							✓
CO4		✓	✓				1.					✓
CO5	✓	✓		✓								✓

REFERENCES:

1. David Wyatt. 'Aircraft Flight Instruments and Guidance Systems', Routledge, Taylor & Francis Group, 2015.
2. Doeblin. E. O, Measurement Systems Application and Design, McGraw-Hill, New York, 1999.
3. Harry L. Stilz, Aerospace Telemetry, Vol I to IV, Prentice-Hall Space Technology Series, 1961.
4. Murthy, D.V.S., Transducers and Measurements, McGraw-Hill, 1995.
5. Nagabhushana S. and Sudha L.K. Aircraft Instrumentation and Systems, I.K. International publishing house PVT Ltd, 2010.
6. Pallet, E.H.J. Aircraft Instruments & Integrated systems, Longman Scientific and Technical, McGraw-Hill, 1992.

AV5251 AEROSPACE GUIDANCE AND CONTROL L T P C
3 1 0 4

OBJECTIVES:

- To learn about the aircraft equations of motion and method of linearization.
- To learn about the operating principle of guidance law
- To study about the augmentation systems
- To study longitudinal stability and to design the longitudinal autopilot
- To study lateral stability and to design the lateral autopilot

UNIT I INTRODUCTION 12

Introduction to Guidance and control - Definition, Historical background – Coordinate Frame - Equations of motion – Lineraization.

UNIT II AUGMENTATION SYSTEMS 12

Need for automatic flight control systems, Stability augmentation systems, control augmentation systems, Design of Limited authority and Full Authority Augmentation systems - Gain scheduling concepts.

UNIT III LONGITUDINAL AUTOPILOT 12

Displacement Autopilot -Pitch Orientation Control system, Acceleration Control System, Glide Slope Coupler and Automatic Flare Control and Flight path stabilization, Longitudinal control law design using back stepping algorithm.

UNIT IV LATERAL AUTOPILOT 12

Damping of the Dutch Roll, Methods of Obtaining Coordination, Yaw Orientation Control system, turn compensation, Automatic lateral Beam Guidance. Introduction to Fly-by-wire flight control

systems, Lateral control law design using back stepping algorithm.

UNIT V MISSILE AND LAUNCH VEHICLE GUIDANCE 12

Operating principles and design of guidance laws, homing guidance laws- short range, Medium range and BVR missiles, Launch Vehicle- Introduction, Mission requirements, Implicit guidance schemes, Explicit guidance, Q guidance schemes

TOTAL: 60 PERIODS

OUTCOMES:

Students will be able to:

CO1: Explain the equations governing the aircraft dynamics and the process of linearizing them.
CO2: Define the various guidance schemes and requirements for aircrafts and missiles.
CO3: Apply the principle of stability and control augmentation systems.
CO4: Analyse the oscillatory modes and methods of suppressing them
CO5: Design the controller for lateral, longitudinal and directional control of aircrafts.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓							✓		✓
CO2	✓	✓							✓	✓		
CO3	✓	✓		✓								
CO4	✓	✓	✓		✓							
CO5	✓	✓	✓	✓	✓							✓

REFERENCES:

1. Blake Lock, J.H Automatic control of Aircraft and missiles, John Wiley Sons, New York, 1990.
2. Collinson R.P.G, 'Introduction to Avionics', Chapman and Hall, India, 1996.
3. Garnel. P. & East. D. J, 'Guided Weapon control systems', Pergamon Press, Oxford, 1977.
4. Michael V. Cook 'Flight Dynamics Principles: A Linear Systems Approach to Aircraft Stability and Control', Elsevier, 2013.
5. Nelson R.C, 'Flight stability & Automatic Control', McGraw Hill, 1989.
6. Pierre T. Kabamba, Anouck R. Girard. 'Fundamentals of Aerospace Navigation and Guidance', Cambridge university press, 2014.
7. Stevens B.L & Lewis F.L, 'Aircraft control & simulation', John Wiley Sons, New York, 1992.
8. Thomas R. Yechout, Steven L. Morris, David E. Bossert, Wayne F. Hallgren, James K. Hall— Introduction to Aircraft Flight Mechanics, AIAA Education series, 2014.

VE5251 CMOS ANALOG IC DESIGN L T P C
3 0 0 3

OBJECTIVES:

- To learn the equivalent circuits and models of MOS circuits
- To analyze various biasing circuits
- To design and analyze various differential amplifier architectures
- To design and analyze the frequency response of various differential amplifiers
- To discuss the stability and frequency compensation of feedback amplifiers

UNIT - I SINGLE STAGE AMPLIFIERS 9

Review of MOS physics and equivalent circuits and models. Large and Small signal analysis CS, CG and source follower, miller effect, frequency response of CS, CG and source follower.

UNIT - II CURRENT MIRRORS 9

Current Sources, Basic Current Mirrors, Cascode stages for Current mirrors, Wilson Current Mirror,Widler Current Mirror Large and small signal analysis of current mirrors.

UNIT – III MULTISTAGE DIFFERENTIAL AMPLIFIERS 9

Differential amplifier, Large and small signal analysis of the balanced differential amplifier, device mismatches in differential amplifier, small and large signal analysis of the differential pair with current mirror load, $PSRR^+$, $PSRR^-$ and CMRR of differential amplifiers, small signal analysis of telescopic amplifier, two-stage amplifier and folded cascoded amplifier.

UNIT – IV FREQUENCY RESPONSE OF MULTISTAGE DIFFERENTIAL AMPLIFIERS 9

Frequency response of differential amplifier-transfer function method, Miller effect, Dominant-Pole approximation, Upper Cutoff frequency-zero-value time constant method,UGF-short circuit time constant method, frequency response of telescopic cascoded, folded cascaded and two-stage amplifiers.

UNIT – V STABILITY AND FREQUENCY COMPENSATION OF FEEDBACK AMPLIFIERS 9

Properties and types of negative feedback circuits, feedback configurations, effect of loading in feedback networks, feedback circuit analysis using return ratio modelling input and output port in feedback network, the relation between gain and bandwidth in feedback amplifiers, phase margin, frequency compensation, compensation of two stage MOS amplifiers.

TOTAL: 45 PERIODS

OUTCOMES:

On successful completion of this course, students will be able to

CO1: Analyze and design CMOS analog IC building blocks
CO2: Design the various current mirror biasing circuits
CO3: Analyze and Design the various single and multistage differential amplifier architectures
CO4: Analyze the frequency response of single and multi-stage differential amplifiers
CO5: Analyze and design various feedback amplifiers with compensation

REFERENCES:

1. Gray, Hurst, Lewis, Meyar, “Analysis and Design of Analog Integrated Circuits” Fifth Edition John Wiley, 2016.
2. Behzad Razavi, “Design of Analog CMOS Integrated Circuits”, Twelfth Reprint, Tata McGraw Hill, 2012.
3. Phillip E. Allen, Douglas R.Holberg, “CMOS Analog Circuit Design”, Third edition, Oxford University Press, 2011.
4. Jacob Baker “CMOS: Circuit Design, Layout, and Simulation, Third Edition”, Wiley IEEE Press 2010.
5. Kenneth William Martin, David Johns, “Analog Integrated Circuit Design”, , Wiley India, 2008.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓		✓	✓		✓
CO2	✓		✓	✓	✓	
CO3	✓		✓	✓		
CO4	✓		✓		✓	
CO5	✓		✓	✓		

AM5071 AUTOMOTIVE ELECTRICAL AND ELECTRONICS L T P C
3 0 0 3

OBJECTIVES:

- To impart knowledge to the students in the principles of operation and constructional details of various Automotive Electrical and Electronic Systems
- To understand the need for starter batteries, starter motor and alternator in the vehicle.
- To differentiate the conventional and modern vehicle architecture and the data transfer among the different electronic control unit using different communication protocols
- To list common types of sensor and actuators used in vehicles.
- To understand dash – Board Instruments, various sensors and networking in vehicles.

UNIT I BATTERY AND STARTING SYSTEMS 9

Types of Batteries – Principle, Construction and Electrochemical action of Lead – Acid battery, Electrolyte, Efficiency, Rating, Charging, Testing and Maintenance. Starting System, Starter Motors – Characteristics, Capacity requirements. Drive Mechanisms. Starter Switches.

UNIT II CHARGING AND LIGHTING SYSTEMS 9

D.C. Generators and Alternators their Characteristics. Control cutout, Electrical, Electromechanical and electronic regulators. Regulations for charging. Wiring Requirements, Insulated and earth return system, details of head light and side light, LED lighting system, head light dazzling and preventive methods. Lighting design.

UNIT III ELECTRONIC IGNITION AND INJECTION SYSTEMS 9

Types of electronic ignition systems - variable ignition timing, distributor less ignition. Spark timing control. TBI, MPFI, GDI Systems. Engine mapping.

UNIT IV ELECTRICAL SYSTEMS 9

Warning and alarm instruments : Brake actuation warning system, traficators, flash system, oil pressure warning system, engine over heat warning system, air pressure warning system, speed warning system, door lock indicators, neutral gear indicator, horn design, permanent magnet horn, air & music horns. Wind shield wiper. window washer, instrument wiring system and electromagnetic interference suppression, wiring circuits for instruments, electronic instruments, dash board illumination.

UNIT V MICROPROCESSOR IN AUTOMOBILES 9

Microprocessor And Microcomputer controlled devices in automobiles such as instrument cluster, Voice warning system, Travel information system, Keyless entry system. Environmental requirements (vibration, Temperature and EMI).

TOTAL : 45 PERIODS

OUTCOMES:

At the end of this course the student should be able to

- Define the glossary related to vehicle electrical and electronic system
- Understand the need for starter batteries, starter motor and alternator in the vehicle.
- Differentiate the conventional and modern vehicle architecture and the data transfer among the different electronic control unit using different communication protocols
- List common types of sensor and actuators used in vehicles.
- Understand networking in vehicles.

REFERENCES:

1. Judge. A.W., Modern Electrical Equipment of Automobiles, Chapman & Hall, London, 1992.
2. William B. Ribbens -Understanding Automotive Electronics, 5th edition- Butter worth Heinemann, 1998

3. Young. A.P., & Griffiths. L., Automobile Electrical Equipment, English Language Book Society & New Press, 1990.
4. Vinal. G.W., Storage Batteries, John Wiley & Sons inc., New York, 1985.
5. Crouse.W.H., Automobile Electrical Equipment, McGraw Hill Book Co Inc., New York, 1980.
6. Spreadbury.F.G., Electrical Ignition Equipment, Constable & Co Ltd., London, 1962.
7. Robert N Brady Automotive Computers and Digital Instrumentation, Prentice Hall, Eagle Wood Cliffs, New Jersey, 1988.

CP5073 CLOUD COMPUTING TECHNOLOGIES LT P C
3 0 2 4

OBJECTIVES:

- To understand the concept of cloud and utility computing.
- To understand the various issues in cloud computing.
- To familiarize themselves with the lead players in cloud.
- To appreciate the emergence of cloud as the next generation computing paradigm.
- To be able to set up a private cloud.

UNIT I INTRODUCTION 9+6

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+6

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+6

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+6

Apache Hadoop – HadoopMapReduce –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+6

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 +30 = 75 PERIODS

OUTCOMES:

Upon completion of the course, the student will be able to

- Articulate the main concepts, key technologies, strengths and limitations of cloud computing.
- Identify the architecture, infrastructure and delivery models of cloud computing.
- Explain the core issues of cloud computing such as security, privacy and interoperability.
- Choose the appropriate technologies, algorithms and approaches for the related issues.

- 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”, Tata McGraw-Hill,2013.
3. Toby Velte, Anthony Velte, Robert C. Elsenpeter, “Cloud Computing, A Practical Approach”,Tata McGraw-Hill Edition, 2010.
4. Arshdeep Bahga, Vijay Madisetti, “Cloud Computing: A Hands-On Approach”, Universities Press(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 and Strategy”, CRC Press, 2010.

CO	**PO**						**PSO**		
	1	2	3	4	5	6	1	2	3
1.	√		√	√			√	√	
2.	√		√	√			√	√	
3.	√		√	√			√	√	
4.	√		√	√		√	√	√	
5.	√		√	√		√	√	√	√

BD5151 **BIG DATA MINING AND ANALYTICS** **L T P C**
3 0 0 3

OBJECTIVES:

- To understand the computational approaches to Modeling, Feature Extraction.
- To understand the need and application of Map Reduce.
- To understand the various search algorithms applicable to Big Data.
- To analyze and interpret streaming data.
- To learn how to handle large data sets in main memory.
- To learn the various clustering techniques applicable to Big Data.

UNIT I DATA MINING AND LARGE SCALE FILES **9**

Introduction to Statistical modeling – Machine Learning – Computational approaches to modeling – Summarization – Feature Extraction – Statistical Limits on Data Mining – Distributed File Systems– Map-reduce – Algorithms using Map Reduce – Efficiency of Cluster Computing Techniques.

UNIT II SIMILAR ITEMS **9**

Nearest Neighbor Search – Shingling of Documents – Similarity preserving summaries – Locality sensitive hashing for documents – Distance Measures – Theory of Locality Sensitive Functions – LSH Families – Methods for High Degree of Similarities.

UNIT III MINING DATA STREAMS **9**

Stream Data Model – Sampling Data in the Stream – Filtering Streams – Counting Distance Elements in a Stream – Estimating Moments – Counting Ones in Window – Decaying Windows

UNIT IV LINK ANALYSIS AND FREQUENT ITEMSETS **9**

Page Rank –Efficient Computation – Topic Sensitive Page Rank – Link Spam – Market Basket Model – Apriori algorithm – Handling Larger Datasets in Main Memory – Limited Pass Algorithm – Counting Frequent Item sets.

UNIT V CLUSTERING **9**

Introduction to Clustering Techniques – Hierarchical Clustering –Algorithms – K-Means – CURE – Clustering in Non – Euclidean Spaces – Streams and Parallelism – **Case Study:** Advertising on the Web – Recommendation Systems

TOTAL : 45 PERIODS

OUTCOMES:

Upon completion of the course, the student will be able to

- Design algorithms by employing Map Reduce technique for solving Big Data problems.
- Identify similarities using appropriate measures.
- Point out problems associated with streaming data and handle them.
- Discuss algorithms for link analysis and frequent item set mining.
- Design solutions for problems in Big Data by suggesting appropriate clustering techniques.

REFERENCES:

1. Jure Leskovec, AnandRajaraman, Jeffrey David Ullman, “Mining of Massive Datasets”,Cambridge University Press, Second Edition, 2014.
2. Jiawei Han, MichelineKamber, Jian Pei, “Data Mining Concepts and Techniques”, Morgan Kaufman Publications, Third Edition, 2011.
3. Ian H.Witten, Eibe Frank “Data Mining – Practical Machine Learning Tools and Techniques”, Morgan Kaufman Publications, Third Edition, 2011.

4. David Hand, HeikkiMannila and Padhraic Smyth, “Principles of Data Mining”, MIT Press,2001.

CO	PO						PSO		
	1	2	3	4	5	6	1	2	3
1.	√		√	√			√	√	√
2.			√	√		√	√		
3.	√		√	√			√	√	√
4.	√		√	√			√	√	√
5.	√		√	√			√	√	√

OPEN ELECTIVE COURSES (OEC)

OE5091 BUSINESS DATA ANALYTICS LT P C
3 0 0 3

OBJECTIVES:

- To understand the basics of business analytics and its life cycle.
- To gain knowledge about fundamental business analytics.
- To learn modeling for uncertainty and statistical inference.
- To understand analytics using Hadoop and Map Reduce frameworks.
- To acquire insight on other analytical frameworks.

UNIT I OVERVIEW OF BUSINESS ANALYTICS 9

Introduction – Drivers for Business Analytics – Applications of Business Analytics: Marketing and Sales, Human Resource, Healthcare, Product Design, Service Design, Customer Service and Support – Skills Required for a Business Analyst – Framework for Business Analytics Life Cycle for Business Analytics Process.

Suggested Activities:

- Case studies on applications involving business analytics.
- Converting real time decision making problems into hypothesis.
- Group discussion on entrepreneurial opportunities in Business Analytics.

Suggested Evaluation Methods:

- Assignment on business scenario and business analytical life cycle process.
- Group presentation on big data applications with societal need.
- Quiz on case studies.

UNIT II ESSENTIALS OF BUSINESS ANALYTICS 9

Descriptive Statistics – Using Data – Types of Data – Data Distribution Metrics: Frequency, Mean, Median, Mode, Range, Variance, Standard Deviation, Percentile, Quartile, z-Score, Covariance, Correlation – Data Visualization: Tables, Charts, Line Charts, Bar and Column Chart, Bubble Chart, Heat Map – Data Dashboards.

Suggested Activities:

- Solve numerical problems on basic statistics.
- Explore chart wizard in MS Excel Case using sample real time data for data visualization.
- Use R tool for data visualization.

Suggested Evaluation Methods:

- Assignment on descriptive analytics using benchmark data.
- Quiz on data visualization for univariate, bivariate data.

UNIT III MODELING UNCERTAINTY AND STATISTICAL INFERENCE 9

Modeling Uncertainty: Events and Probabilities – Conditional Probability – Random Variables – Discrete Probability Distributions – Continuous Probability Distribution – Statistical Inference: Data Sampling – Selecting a Sample – Point Estimation – Sampling Distributions – Interval Estimation – Hypothesis Testing.

Suggested Activities:

- Solving numerical problems in sampling, probability, probability distributions and hypothesis testing.

- Converting real time decision making problems into hypothesis.

Suggested Evaluation Methods:
- Assignments on hypothesis testing.
- Group presentation on real time applications involving data sampling and hypothesis testing.
- Quizzes on topics like sampling and probability.

UNIT IV ANALYTICS USING HADOOP AND MAPREDUCE FRAMEWORK 9

Introducing Hadoop– RDBMS versus Hadoop–Hadoop Overview – HDFS (Hadoop Distributed File System) – Processing Data with Hadoop– Introduction to MapReduce – Features of MapReduce – Algorithms Using Map-Reduce: Matrix-Vector Multiplication, Relational Algebra Operations, Grouping and Aggregation – Extensions to MapReduce.

Suggested Activities:
- Practical – Install and configure Hadoop.
- Practical – Use web based tools to monitor Hadoop setup.
- Practical – Design and develop MapReduce tasks for word count, searching involving text corpus etc.

Suggested Evaluation Methods:
- Evaluation of the practical implementations.
- Quizzes on topics like HDFS and extensions to MapReduce.

UNIT V OTHER DATA ANALYTICAL FRAMEWORKS 9

Overview of Application development Languages for Hadoop – PigLatin – Hive – Hive Query Language (HQL) – Introduction to Pentaho, JAQL – Introduction to Apache: Sqoop, Drill and Spark, Cloudera Impala – Introduction to NoSQL Databases – Hbase and MongoDB.

Suggested Activities:
- Practical – Installation of NoSQL database like MongoDB.
- Practical – Demonstration on Sharding in MongoDB.
- Practical – Install and run Pig
- Practical – Write PigLatin scripts to sort, group, join, project, and filter data.
- Design and develop algorithms to be executed in MapReduce involving numerical methods for analytics.

Suggested Evaluation Methods:
- Mini Project (Group) – Real time data collection, saving in NoSQL, implement analytical techniques using Map-Reduce Tasks and Result Projection.

TOTAL: 45 PERIODS

OUTCOMES:

On completion of the course, the student will be able to:
- Identify the real world business problems and model with analytical solutions.
- Solve analytical problem with relevant mathematics background knowledge.
- Convert any real world decision making problem to hypothesis and apply suitable statistical testing.
- Write and Demonstrate simple applications involving analytics using Hadoop and MapReduce
- Use open source frameworks for modeling and storing data.
- Apply suitable visualization technique using R for visualizing voluminous data.

REFERENCES:

1. VigneshPrajapati, “Big Data Analytics with R and Hadoop”, Packt Publishing, 2013.
2. Umesh R Hodeghatta, UmeshaNayak, “Business Analytics Using R – A Practical Approach”, Apress, 2017.

3. AnandRajaraman, Jeffrey David Ullman, “Mining of Massive Datasets”, Cambridge University Press, 2012.
4. Jeffrey D. Camm, James J. Cochran, Michael J. Fry, Jeffrey W. Ohlmann, David R. Anderson, “Essentials of Business Analytics”, Cengage Learning, second Edition, 2016.
5. U. Dinesh Kumar, “Business Analytics: The Science of Data-Driven Decision Making”, Wiley, 2017.
6. A. Ohri, “R for Business Analytics”, Springer, 2012
7. Rui Miguel Forte, “Mastering Predictive Analytics with R”, Packt Publication, 2015.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	2	3	1
CO2	2	1	1	2	1	1
CO3	1	1	2	3	3	1
CO4	2	2	1	2	1	1
CO5	1	1	2	2	1	1
CO6	1	1	1	3	2	1

OE5092 INDUSTRIAL SAFETY LT P C
3 0 0 3

OBJECTIVES:

- Summarize basics of industrial safety
- Describe fundamentals of maintenance engineering
- Explain wear and corrosion
- Illustrate fault tracing
- Identify preventive and periodic maintenance

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.

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, I. Any one machine tool, ii. Pump iii.

Air compressor, iv. Internal combustion engine, v. Boiler, vi. 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 of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

TOTAL: 45 PERIODS

OUTCOMES:

CO1: Ability to summarize basics of industrial safety
CO2: Ability to describe fundamentals of maintenance engineering
CO3: Ability to explain wear and corrosion
CO4: Ability to illustrate fault tracing
CO5: Ability to identify preventive and periodic maintenance

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓											
CO3	✓	✓	✓									
CO4	✓	✓	✓									
CO5	✓	✓	✓									

REFERENCES:

1. Audels, Pump-hydraulic Compressors, Mcgrew Hill Publication, 1978.
2. Garg H P,Maintenance Engineering, S. Chand and Company,1987.
3. Hans F. Winterkorn ,Foundation Engineering Handbook, Chapman & Hall London,2013.
4. Higgins & Morrow , Maintenance Engineering Handbook, Eighth Edition,2008

OE5093 OPERATIONS RESEARCH LT P C
3 0 0 3

OBJECTIVES:

- Solve linear programming problem and solve using graphical method.
- Solve LPP using simplex method
- Solve transportation , assignment problems
- Solve project management problems
- Solve scheduling problems

UNIT I LINEAR PROGRAMMING 9

Introduction to Operations Research – assumptions of linear programming problems - Formulations of linear programming problem – Graphical method

UNIT II ADVANCES IN LINEAR PROGRAMMING 9

Solutions to LPP using simplex algorithm- Revised simplex method - primal dual relationships – Dual simplex algorithm - Sensitivity analysis

UNIT III NETWORK ANALYSIS – I 9

Transportation problems -Northwest corner rule, least cost method,Voges's approximation method - Assignment problem -Hungarian algorithm

UNIT IV NETWORK ANALYSIS – II 9

Shortest path problem: Dijkstra's algorithms, Floyds algorithm, systematic method -CPM/PERT

UNIT V NETWORK ANALYSIS – III 9

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models

TOTAL: 45 PERIODS

OUTCOMES:

CO1: To formulate linear programming problem and solve using graphical method.
CO2: To solve LPP using simplex method
CO3: To formulate and solve transportation, assignment problems
CO4: To solve project management problems
CO5: To solve scheduling problems

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓											
CO3	✓	✓	✓									
CO4	✓	✓	✓									
CO5	✓	✓	✓									

REFERENCES:

1. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010
2. Hitler Libermann, Operations Research: McGraw Hill Pub. 2009
3. Pant J C, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Pannerselvam, Operations Research: Prentice Hall of India 2010
5. Taha H A, Operations Research, An Introduction, PHI, 2008

OE5094 COST MANAGEMENT OF ENGINEERING PROJECTS L T P C
3 0 0 3

OBJECTIVES:

- Summarize the costing concepts and their role in decision making
- Infer the project management concepts and their various aspects in selection
- Interpret costing concepts with project execution
- Develop knowledge of costing techniques in service sector and various budgetary control techniques
- Illustrate with quantitative techniques in cost management

UNIT I INTRODUCTION TO COSTING *CONCEPTS* 9

Objectives of a Costing System; Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost; Creation of a Database for operational control.

UNIT II INTRODUCTION TO PROJECT MANAGEMENT 9

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities, Detailed Engineering activities, Pre project execution main clearances and

documents, Project team: Role of each member, Importance Project site: Data required with significance, Project contracts.

UNIT III PROJECT EXECUTION AND COSTING CONCEPTS 9

Project execution Project cost control, Bar charts and Network diagram, Project commissioning: mechanical and process, Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis, Various decision-making problems, Pricing strategies: Pareto Analysis, Target costing, Life Cycle Costing.

UNIT IV COSTING OF SERVICE SECTOR AND BUDGETERY CONTROL 9

Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis, Budgetary Control: Flexible Budgets; Performance budgets; Zero-based budgets.

UNIT V QUANTITATIVE TECHNIQUES FOR COST MANAGEMENT 9

Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Learning Curve Theory.

TOTAL: 45 PERIODS

OUTCOMES

CO1 – Understand the costing concepts and their role in decision making
CO2–Understand the project management concepts and their various aspects in selection
CO3–Interpret costing concepts with project execution
CO4–Gain knowledge of costing techniques in service sector and various budgetary control techniques
CO5 - Become familiar with quantitative techniques in cost management

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓		✓			✓	✓		✓	✓
CO2	✓	✓	✓		✓				✓		✓	✓
CO3	✓	✓	✓		✓	✓					✓	✓
CO4	✓	✓	✓		✓		✓				✓	✓
CO5	✓	✓	✓		✓	✓	✓				✓	✓

REFERENCES:

1. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher, 1991
2. Charles T. Horngren and George Foster, Advanced Management Accounting, 1988
3. Charles T. Horngren et al Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi, 2011
4. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting, 2003
5. Vohra N.D., Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd, 2007

OE5095 COMPOSITE MATERIALS L T P C
3 0 0 3

OBJECTIVES:

- Summarize the characteristics of composite materials and effect of reinforcement in composite materials.
- Identify the various reinforcements used in composite materials.
- Compare the manufacturing process of metal matrix composites.
- Understand the manufacturing processes of polymer matrix composites.
- Analyze the strength of composite materials.

UNIT I INTRODUCTION 9

Definition – Classification and characteristics of Composite materials - Advantages and application of composites - Functional requirements of reinforcement and matrix - Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

UNIT II REINFORCEMENTS 9

Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers - Properties and applications of whiskers, particle reinforcements - Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures - Isostrain and Isostress conditions.

UNIT III MANUFACTURING OF METAL MATRIX COMPOSITES 9

Casting – Solid State diffusion technique - Cladding – Hot isostatic pressing - Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving - Properties and applications.

UNIT IV MANUFACTURING OF POLYMER MATRIX COMPOSITES 9

Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding - Properties and applications.

UNIT V STRENGTH 9

Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

TOTAL: 45 PERIODS

OUTCOMES:

- CO1 - Know the characteristics of composite materials and effect of reinforcement in composite materials.
- CO2 – Know the various reinforcements used in composite materials.
- CO3 – Understand the manufacturing processes of metal matrix composites.
- CO4 – Understand the manufacturing processes of polymer matrix composites.
- CO5 – Analyze the strength of composite materials.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		✓	✓	✓								
CO2		✓✓	✓	✓	✓						✓	
CO3			✓	✓	✓		✓				✓	
CO4			✓	✓	✓		✓				✓	
CO5				✓	✓		✓					

REFERENCES:

1. Cahn R.W. - Material Science and Technology – Vol 13 – Composites, VCH, WestGermany.
2. Callister, W.D Jr., Adapted by Balasubramaniam R, Materials Science and Engineering, An introduction, John Wiley & Sons, NY, Indian edition, 2007.
3. Chawla K.K., Composite Materials, 2013.
4. Lubin.G, Hand Book of Composite Materials, 2013.

OE5096 **WASTE TO ENERGY** **L T P C**
3 0 0 3

OBJECTIVES:

- Interpret the various types of wastes from which energy can be generated
- Develop knowledge on biomass pyrolysis process and its applications
- Develop knowledge on various types of biomass gasifiers and their operations
- Invent knowledge on biomass combustors and its applications on generating energy
- Summarize the principles of bio-energy systems and their features

UNITI INTRODUCTION TO EXTRACTION OF ENERGY FROM WASTE 9

Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

UNITII BIOMASS PYROLYSIS 9

Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

UNITIII BIOMASS GASIFICATION 9

Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

UNITIV BIOMASS COMBUSTION 9

Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

UNITV BIO ENERGY 9

Properties of biogas (Calorific value and composition), Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production -Urban waste to energy conversion - Biomass energy programme in India.

TOTAL: 45 PERIODS

OUTCOMES:

CO1 – Understand the various types of wastes from which energy can be generated
CO2 – Gain knowledge on biomass pyrolysis process and its applications
CO3 – Develop knowledge on various types of biomass gasifiers and their operations
CO4 – Gain knowledge on biomass combustors and its applications on generating energy
CO5 – Understand the principles of bio-energy systems and their features

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓		✓									✓
CO2	✓		✓									✓
CO3	✓	✓	✓		✓							✓
CO4	✓	✓	✓		✓		✓					✓
CO5	✓	✓	✓		✓							✓

REFERENCES:

1. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
2. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.

AUDIT COURSES (AC)

AX5091 ENGLISH FOR RESEARCH PAPER WRITING L T P C
2 0 0 0

OBJECTIVES

- Teach how to improve writing skills and level of readability
- Tell about what to write in each section
- Summarize the skills needed when writing a Title
- Infer the skills needed when writing the Conclusion
- Ensure the quality of paper at very first-time submission

UNIT I INTRODUCTION TO RESEARCH PAPER WRITING 6

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

UNIT II PRESENTATION SKILLS 6

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Introduction

UNIT III TITLE WRITING SKILLS 6

Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check

UNIT IV RESULT WRITING SKILLS 6

Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions

UNIT V VERIFICATION SKILLS 6

Useful phrases, checking Plagiarism, how to ensure paper is as good as it could possibly be the first-time submission

TOTAL: 30 PERIODS

OUTCOMES

CO1 –Understand that how to improve your writing skills and level of readability
CO2 – Learn about what to write in each section
CO3 – Understand the skills needed when writing a Title
CO4 – Understand the skills needed when writing the Conclusion
CO5 – Ensure the good quality of paper at very first-time submission

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										✓		✓

CO2										✓		✓
CO3										✓		✓
CO4										✓		✓
CO5										✓		✓

REFERENCES

1. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011
2. Day R How to Write and Publish a Scientific Paper, Cambridge University Press 2006
3. Goldbort R Writing for Science, Yale University Press (available on Google Books) 2006
4. Highman N, Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book 1998.

AX5092 DISASTER MANAGEMENT L T P C
2 0 0 0

OBJECTIVES

- Summarize basics of disaster
- Explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.
- Illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
- Describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
- Develop the strengths and weaknesses of disaster management approaches

UNIT I INTRODUCTION 6

Disaster: Definition, Factors and Significance; Difference between Hazard And Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.

UNIT II REPERCUSSIONS OF DISASTERS AND HAZARDS 6

Economic Damage, Loss of Human and Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.

UNIT III DISASTER PRONE AREAS IN INDIA 6

Study of Seismic Zones; Areas Prone To Floods and Droughts, Landslides And Avalanches; Areas Prone To Cyclonic and Coastal Hazards with Special Reference To Tsunami; Post-Disaster Diseases and Epidemics

UNIT IV DISASTER PREPAREDNESS AND MANAGEMENT 6

Preparedness: Monitoring Of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological And Other Agencies, Media Reports: Governmental and Community Preparedness.

UNIT V RISK ASSESSMENT 6

Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival

TOTAL : 30 PERIODS

OUTCOMES

CO1: Ability to summarize basics of disaster
CO2: Ability to explain a critical understanding of key concepts in disaster riskreduction and humanitarian response.
CO3: Ability to illustratedisaster risk reduction and humanitarian response policy and practice from multiple perspectives.
CO4: Ability to describean understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
CO5: Ability to develop the strengths and weaknesses of disaster management approaches

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓											
CO3	✓	✓	✓									
CO4	✓	✓	✓									
CO5	✓	✓	✓									

REFERENCES

1. Goel S. L., Disaster Administration And Management Text And Case Studies",Deep & Deep Publication Pvt. Ltd., New Delhi,2009.
2. NishithaRai, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'NewRoyal book Company,2007.
3. Sahni, PardeepEt.Al. ," Disaster Mitigation Experiences And Reflections", Prentice Hall OfIndia, New Delhi,2001.

AX5093 SANSKRIT FOR TECHNICAL KNOWLEDGE L T P C
2 0 0 0

OBJECTIVES

- Illustrate the basic sanskrit language.
- Recognize sanskrit, the scientific language in the world.
- Appraise learning of sanskrit to improve brain functioning.
- Relate sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power.
- Extract huge knowledge from ancient literature.

UNIT I ALPHABETS 6

Alphabets in Sanskrit

UNIT II TENSES AND SENTENCES 6

Past/Present/Future Tense - Simple Sentences

UNIT III ORDER AND ROOTS 6

Order - Introduction of roots

UNIT IV SANSKRIT LITERATURE 6

Technical information about Sanskrit Literature

UNIT V TECHNICAL CONCEPTS OF ENGINEERING 6

Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics

TOTAL: 30 PERIODS

OUTCOMES

- CO1 - Understanding basic Sanskrit language.
- CO2 - Write sentences.
- CO3 - Know the order and roots of Sanskrit.
- CO4 - Know about technical information about Sanskrit literature.
- CO5 - Understand the technical concepts of Engineering.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										✓		✓
CO2										✓		✓
CO3												✓
CO4												✓
CO5												✓

REFERENCES

1. “Abhyaspustakam” – Dr. Vishwas, Samskrita-Bharti Publication, New Delhi
2. “Teach Yourself Sanskrit” Prathama Deeksha-Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. “India’s Glorious Scientific Tradition” Suresh Soni, Ocean books (P) Ltd., New Delhi, 2017.

AX5094 **VALUE EDUCATION** **L T P C**

2 0 0 0

OBJECTIVES

Students will be able to

- Understand value of education and self-development
- Imbibe good values in students
- Let the should know about the importance of character

UNIT I

Values and self-development–Social values and individual attitudes. Work ethics, Indian vision of humanism. Moral and non-moral valuation. Standards and principles. Value judgements

UNIT II

Importance of cultivation of values. Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness. Honesty, Humanity. Power of faith, National Unity. Patriotism. Love for nature, Discipline

UNIT III

Personality and Behavior Development-Soul and Scientific attitude. Positive Thinking. Integrity and discipline. Punctuality, Love and Kindness. Avoid fault Thinking. Free from anger, Dignity of labour. Universal brother hood and religious tolerance. True friendship. Happiness Vs suffering, love for truth. Aware of self-destructive habits. Association and Cooperation. Doing best for saving nature

UNIT IV

Character and Competence–Holy books vs Blind faith. Self-management and Good health. Science of reincarnation. Equality, Nonviolence, Humility, Role of Women. All religions and same message. Mind your Mind, Self-control. Honesty, Studying effectively.

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to

- Knowledge of self-development.
- Learn the importance of Human values.
- Developing the overall personality.

Suggested reading

1. Chakroborty, S.K.“Values and Ethics for organizations Theory and practice”, Oxford University, Press, New Delhi

AX5095 **CONSTITUTION OF INDIA** **L T P C**
2 0 0 0

OBJECTIVES

Students will be able to:

- Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
- To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional
- Role and entitlement to civil and economic rights as well as the emergence nation hood in the early years of Indian nationalism.
- To address the role of socialism in India after the commencement of the Bolshevik Revolutionin1917and its impact on the initial drafting of the Indian Constitution.

UNIT I HISTORY OF MAKING OF THE INDIAN CONSTITUTION:

History, Drafting Committee, (Composition & Working)

UNIT II PHILOSOPHY OF THE INDIAN CONSTITUTION:

Preamble, Salient Features

UNIT III CONTOURS OF CONSTITUTIONAL RIGHTS AND DUTIES:

Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.

UNIT IV ORGANS OF GOVERNANCE:

Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions.

UNIT V LOCAL ADMINISTRATION:

District's Administration head: Role and Importance, • Municipalities: Introduction, Mayor and role of Elected Representative, CEO, Municipal Corporation. Pachayati raj: Introduction, PRI: Zila Pachayat. Elected officials and their roles, CEO Zila Pachayat: Position and role. Block level: Organizational Hierarchy(Different departments), Village level:Role of Elected and Appointed officials, Importance of grass root democracy.

UNIT VI ELECTION COMMISSION:

Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners - Institute and Bodies for the welfare of SC/ST/OBC and women.

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to:

- Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
- Discuss the intellectual origins of the framework of argument that informed the conceptualization
- of social reforms leading to revolution in India.
- Discuss the circumstances surrounding the foundation of the Congress Socialist Party[CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
- Discuss the passage of the Hindu Code Bill of 1956.

Suggested reading

1. The Constitution of India,1950(Bare Act),Government Publication.

developing countries?

- What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
- How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

Suggested reading

1. Ackers J, HardmanF (2001) Classroom interaction in Kenyan primary schools, Compare, 31(2): 245-261.
2. Agrawal M (2004)Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36(3):361-379.
3. Akyeampong K (2003) Teacher training in Ghana-does it count? Multi-site teacher education research project (MUSTER) country report 1.London:DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33(3): 272–282.
5. Alexander RJ(2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.
6. Chavan M(2003) Read India: Amass scale, rapid, 'learning to read' campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf.

AX5097 STRESS MANAGEMENT BY YOGA

L	T	P	C
2	0	0	0

OBJECTIVES

- To achieve overall health of body and mind
- To overcome stress

UNIT I

Definitions of Eight parts of yoga.(Ashtanga)

UNIT II

Yam and Niyam - Do's and Don't's in life - i) Ahinsa, satya, astheya, bramhacharya and aparigraha, ii) Ahinsa, satya, astheya, bramhacharya and aparigraha.

UNIT III

Asan and Pranayam - Various yog poses and their benefits for mind & body - Regularization of breathing techniques and its effects-Types of pranayam

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to:

- Develop healthy mind in a healthy body thus improving social health also
- Improve efficiency

SUGGESTED READING

1. 'Yogic Asanas for Group Tarining-Part-I":Janardan Swami Yoga bhyasi Mandal, Nagpur
2. "Rajayoga or conquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata

AX5098	PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS	L T P C 2 0 0 0

OBJECTIVES

- To learn to achieve the highest goal happily
- To become a person with stable mind, pleasing personality and determination
- To awaken wisdom in students

UNIT I

Neetisatakam-holistic development of personality - Verses- 19,20,21,22 (wisdom) - Verses- 29,31,32 (pride & heroism) – Verses- 26,28,63,65 (virtue) - Verses- 52,53,59 (dont's) - Verses- 71,73,75,78 (do's)

UNIT II

Approach to day to day work and duties - Shrimad Bhagwad Geeta: Chapter 2-Verses 41, 47,48 - Chapter 3-Verses 13, 21, 27, 35 Chapter 6-Verses 5,13,17,23, 35 - Chapter 18-Verses 45, 46, 48.

UNIT III

Statements of basic knowledge - Shrimad Bhagwad Geeta: Chapter2-Verses 56, 62, 68 Chapter 12 - Verses 13, 14, 15, 16,17, 18 - Personality of role model - shrimad bhagwad geeta - Chapter2-Verses 17, Chapter 3-Verses 36,37,42 - Chapter 4-Verses 18, 38,39 Chapter18 – Verses 37,38,63

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to

- Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life
- The person who has studied Geeta will lead the nation and man kind to peace and prosperity
- Study of Neet is hatakam will help in developing versatile personality of students.

Suggested reading

1. Gopinath, Rashtriya Sanskrit Sansthanam P, Bhartrihari's Three Satakam, Niti-sringar-vairagya, New Delhi,2010
2. Swami Swarupananda , Srimad Bhagavad Gita, Advaita Ashram, Publication Department, Kolkata, 2016.