NOORUL ISLAM CENTRE FOR HIGHER EDUCATION

(Deemed to be University Under Section 3 of the UGC Act, 1956)
Kumaracoil, Thuckalay

DEPARTMENT OF

ELECTRONICS AND INSTRUMENTATION ENGINEERING

M.E.CONTROL AND INSTRUMENTATION ENGINEERING

CURRICULUM AND SYLLABI

REGULATION 20213

NOORUL ISLAM CENTRE FOR HIGHER EDUCATION, Kumaracoil

Regulation: 2023

Curriculum and Syllabi

M.E Programme

DEPARTMENT OF ELECTRONICS AND INSTRUMENTATION ENGINEERING

M.E. CONTROL AND INSTRUMENTATION ENGINEERING

Vision of the University

To be recognized by the Government and society at large as an institution able to deliver excellence with relevance in the field of higher education and research focusing on the needs of the nation in tune with the technological revolution to cope with the knowledge explosion and global competence.

Mission of the University

To develop the institution as a Centre of Excellence, keeping pace with the advances in the field, so as to provide quality higher education to the students and instill in them high standards of discipline and ethics so that they become enlightened individuals in the service of humanity and to carry out focused research in the frontier areas of science and technology.

Faculty of Electrical and Electronics Engineering

Department of Electronics and Instrumentation Engineering

Vision of the Department

To develop innovative, globally competent and high quality instrumentation engineers and entrepreneurs who meet the demands of modern industrial world with societal, environmental and human values.

Mission of the Department

To provide students with a supportive learning environment, equipping them with electronics, instrumentation, control and automation skills to meet industry demands while fostering continuous learning and instilling values of discipline and ethics.

Description of the programme

The Master of Engineering (ME) program in Control and Instrumentation Engineering is framed for the students seeking advanced expertise in the field. The curriculum encompasses a wide scope of advanced topics, including control system design, process control, dynamic control systems, piping & instrumentation, and industrial automation. Elective courses offer opportunities to explore specialized areas such as applied bio-medical instrumentation, robotics and automation, and digital signal processing. Practical training, including laboratory sessions and project work, is an integral part of the program, providing students with hands-on experience and skills applicable to real-world scenarios. Furthermore, the program emphasizes research skills, enabling student's expertise in various domains such as control theory, sensor technology, instrumentation design, automation systems, and emerging technologies like the IoT and artificial intelligence.

Programme Educational Objectives - PEO	
PEO-01	Equip graduates with advanced knowledge and skills in Control and Instrumentation Engineering, enabling them to excel in industries, research, and higher education.
PEO-02	Develop the ability to solve complex engineering problems through a strong foundation in mathematical modeling, system dynamics, and control system design.
PEO-03	Train graduates to design, develop, and implement innovative control and instrumentation systems that address real-world challenges in diverse sectors such as automation, robotics, and process industries.
PEO-04	Foster leadership, teamwork, and ethical professionalism, encouraging graduates to contribute effectively in multidisciplinary environments.
PEO-05	Promote lifelong learning by creating an academic atmosphere that supports continuous skill development, research, and adaptation to emerging technologies.

Graduate Attributes-	
GA-1	**Advanced Engineering Expertise:** Master advanced engineering principles and apply them to design, analyze, and innovate systems that address both present and emerging global challenges across diverse industries.
GA-2	**Leadership in Research and Innovation:** Lead groundbreaking research and foster innovation by identifying opportunities for technological advancements, contributing original ideas that push the boundaries of engineering knowledge.
GA-3	**Sustainable Engineering Practices:** Develop and implement engineering solutions that integrate sustainability, environmental stewardship, and resource efficiency, ensuring the long-term impact and responsibility of all projects.
GA-4	**Ethical and Strategic Decision-Making:** Make informed, ethical decisions in complex engineering contexts, considering societal needs, environmental implications, and the long-term consequences of engineering practices.
GA-5	**Global Competence in Engineering Solutions:** Exhibit a deep understanding of global engineering standards and practices, addressing international challenges and cultural sensitivities in engineering projects to make a broader societal impact.
GA-6	**Technological Agility and Lifelong Learning:** Stay ahead of technological trends and exhibit agility in learning new tools, methodologies, and technologies, ensuring continuous professional growth in a rapidly evolving engineering landscape.

GA-7	**Interdisciplinary and Collaborative Innovation:** Excel in multidisciplinary collaborations, leveraging knowledge from multiple fields to solve complex, large-scale engineering problems that require comprehensive and innovative solutions.
GA-8	**Data-Driven Decision Making:** Employ advanced data analytics, machine learning, and computational tools to derive insights and make informed engineering decisions that improve performance, efficiency, and sustainability.
GA-9	**Entrepreneurial Mindset and Innovation Leadership:** Cultivate an entrepreneurial mindset, translating engineering innovations into viable products, solutions, or services, and leading teams toward commercialization and societal impact.
GA-10	**Safety, Risk, and Crisis Management:** Implement and manage advanced safety protocols and risk mitigation strategies to protect individuals, communities, and ecosystems in engineering practices, particularly in high-stakes and crisis environments.

Programme Outcome - PO	
PO-A	Apply advanced knowledge of mathematics, science, engineering fundamentals, and specialization in control and instrumentation engineering to solve complex industry-related problems.
PO-B	Identify, analyze, and formulate solutions for complex instrumentation and control engineering problems using advanced principles of mathematics and engineering sciences.
PO-C	Design innovative systems, components, or processes for complex control and instrumentation challenges, considering public health, safety, cultural, societal, and environmental factors.
P0-D	Utilize research methodologies, including experimental design, data analysis, and information synthesis, to draw meaningful conclusions and optimize control systems.
PO-E	Select and apply modern engineering tools, techniques, and IT resources for advanced activities like electronic prototyping, system modeling, and process control while understanding their limitations.
PO-F	Assess societal, health, and safety concerns using contextual knowledge and fulfill the responsibilities of a professional control and instrumentation engineer.
PO-G	Recognize the impact of engineering solutions on society and the environment, demonstrating knowledge and commitment to sustainable development practices.
PO-H	Adhere to professional ethics and standards, ensuring ethical responsibility in control and instrumentation engineering practice.
PO-I	Work efficiently as an individual and in leadership roles within multidisciplinary teams, demonstrating collaborative and diverse teamwork capabilities.

PO-J	Communicate effectively in both technical and non-technical environments, including the ability to write detailed reports, design documents, and deliver presentations with clarity.
PO-K	Apply knowledge of engineering and management principles to lead and work collaboratively in multidisciplinary teams, ensuring effective project execution.
PO-L	Embrace life-long learning, staying updated with emerging technologies and advancements in control and instrumentation engineering.

Mapping of Graduate Attributes and Programme Educational Objectives (PEO)

GAs / PEOs	GA-01	GA-02	GA-03	GA-04	GA-05	GA-06	GA-07	GA-08	GA-09	GA-10	GA-11	GA-12
PEO-01	H	H	H	H	A	H	H	N	N	N	H	H
PEO-02	H	H	H	H	A	H	H	N	N	N	H	H
PEO-03	H	H	H	H	A	H	H	N	N	N	H	H
PE0-04	H	H	A	H	A	N	H	N	N	N	H	H
PEO-05	A	A	A	A	H	H	H	N	N	N	A	A

H- Highly Associated A- Associated Not – Not Associated

Mapping of Graduate Attributes and Programme Outcomes (PO)

GAs / PEOs	GA-01	GA-02	GA-03	GA-04	GA-05	GA-06	GA-07	GA-08	GA-09	GA-10	GA-11	GA-12
PO-A	H	H	H	A	H	H	A	A	A	A	N	N
PO-B	H	H	H	A	H	A	A	A	A	A	N	N

PO-C	H	H	H	H	H	H	A	A	A	A	N	N
P0-D	H	A	A	H	A	A	A	A	A	A	N	N
PO-E	A	A	A	A	H	H	A	A	A	A	N	N
PO-F	A	A	H	A	A	A	H	A	A	A	N	N
PO-G	H	A	H	H	H	H	A	A	A	A	N	N
PO-H	H	A	A	H	A	A	A	A	A	A	N	N
PO-I	A	A	A	A	A	A	A	A	A	A	N	N
PO-J	A	A	A	A	A	A	A	A	A	A	N	N
PO-K	A	A	A	A	A	A	A	A	A	A	N	N
PO-L	A	A	A	A	A	A	A	A	A	A	N	N

H- Highly Associated A- Associated Not – Not Associated

Mapping of Programme Educational Objective (PEOs) and Programme Outcomes (POs)

PEO /	PEO-01	PEO-02	PEO-03	PEO-04	PEO-05
PO-A	H	H	H	H	A
PO-B	H	H	H	A	A
PO-C	H	H	H	H	A
P0-D	H	H	H	A	H
PO-E	H	A	H	N	H

PO-F	H	N	H	H	H
PO-G	A	N	N	H	N
PO-H	H	N	N	H	N
PO-I	H	N	N	H	H
PO-J	H	N	N	N	N
PO-K	H	N	N	H	H
PO-L	H	H	H	H	A

H- Highly Associated A- Associated Not – Not Associated

Duration of the programme: 2 Years/ 4 Semesters

Total credits: 68

CURRICULUM & SYLLABI

SEMESTER I

SI. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	MA4501	Advanced Mathematics	3	1	0	4
2.	EI4501	Advanced Process Control	3	0	0	3
3.	EI4502	Control System Design	3	0	0	3
4.	EI4503	Transducers and Smart Instruments	3	0	0	3
5.	EI45**	Programme Elective I	3	0	0	3
6.	OE45D1	Research Methodology and IPR	2	0	0	2
PRACTICAL						
7.	EI4571	Advanced Process Control Laboratory	0	0	4	2
TOTAL			**17**	**1**	**4**	**20**

SEMESTER II

SI. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	EI4504	Dynamic Control System	3	0	0	3

2.	EI4505	Process Instrument Design	3	0	0	3
3.	EI4506	Applied Industrial Instrumentation	3	0	0	3
4.	EI4507	Industrial Automation	3	0	0	3
5.	EI45**	Programme Elective II	3	0	0	3
6.	EI45**	Programme Elective III	3	0	0	3
PRACTICAL						
7.	EI4572	Automation Laboratory	0	0	4	2
TOTAL			**18**	**0**	**4**	**20**

SEMESTER III

SI. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	EI45**	Programme Elective IV	3	0	0	3
2.	XXXXX	Open Elective	3	0	0	3
PRACTICAL						
3.	EI45P1	Project work – Phase I	0	0	12	6
TOTAL			**8**	**0**	**12**	**12**

SEMESTER IV

SI. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
1.	EI45P2	Project work – Phase II	0	0	32	16
TOTAL			0	0	32	16

LIST OF ELECTIVES

SI. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
1.	EI45A1	Applied Bio-Medical Instrumentation	3	0	0	3
2.	EI45A2	Piping and Instrumentation Design	3	0	0	3
3.	EI45A3	Robotics and Automation	3	0	0	3
4.	EI45A4	Design of Embedded Systems	3	0	0	3
5.	EI45A5	Modeling and Simulation	3	0	0	3

6.	EI45A6	Bio Medical Signal Processing	3	0	0	3
7.	EI45A7	Internet of Things and Applications	3	0	0	3
8.	EI45A8	Advanced Digital Signal Processing	3	0	0	3
9.	EI45A9	Intelligent Control Techniques	3	0	0	3
10.	EI45B1	Digital Instrumentation	3	0	0	3
11.	EI45B2	Wireless Sensor Networks	3	0	0	3
12.	EI45B3	Industrial Data Communication	3	0	0	3
13.	EI45B4	Smart Grids	3	0	0	3

OPEN ELECTIVE

SI.No.	SUBJECT CODE	SUBJECT NAME	L	T	P	C
1.	OE45D1	Research Methodology and IPR	2	0	0	2
2.	OE45D2	Business Analytics	3	0	0	3
3.	OE45D3	Industrial Safety	3	0	0	3
4.	OE45D4	Operations Research	3	0	0	3
5.	OE45D5	Composite Materials	3	0	0	3
6.	OE45D6	Waste to Energy	3	0	0	3

SEMESTER I

SI. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	MA4501	Advanced Mathematics	3	1	0	4
2.	EI4501	Advanced Process Control	3	0	0	3
3.	EI4502	Control System Design	3	0	0	3
4.	EI4503	Transducers and Smart Instruments	3	0	0	3
5.	EI45XX	Programme Elective I	3	0	0	3
6.	OE45D1	Research Methodology and IPR	2	0	0	2
PRACTICAL						
7.	EI4571	Advanced Process Control Laboratory	0	0	4	2
TOTAL			**17**	**1**	**4**	**20**

MA4501	ADVANCED MATHEMATICS	L	T	P	C
		3	**1**	**0**	**4**

OBJECTIVES

- The course objective is, the students will be able to apply various methods in Linear Algebra to solve the system of linear equations, use two-dimensional random variables, and correlations in solving application problems apply the ideas of Random Processes and understand the basic characteristic features of a queueing system and acquire skills in analyzing queueing models.

Course Outcome		Cognitive Skill
CO-01	Compute various methods in Linear Algebra to solve the system of linear equations.Using generalized eigenvectors, find the inverse of a singular matrix using the Pseudo inverse method.	R, U, A, E, An
CO-02	Formulate real-life problems and solve them using Linear Programming. Minimize the cost of distributing a product from many sources using TP. Assign a job to some workers so that the jobs are completed at the least cost or time.	R, U, A, E, An
CO-03	The random variable needs the analysis of random phenomena. Apply the concept of the moment, moment generating function. Extended one-dimensional random variables to two-dimensional random variables and analyze. Understand the concept of correlation	R, U, A, E, An

CO-04	Know the concepts which describe the random wave transforms in a probabilistic sense.Trace the nature of random signals.Analyze the random signals in the frequency domain	R, U, A, E, An
CO-05	To understand the basic characteristic features of a queuing system and acquire skills in analyzing queuing models.	R, U, A, E, An

R-Remember,U-Understand,A-Apply,An-Analyze,E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J	PO-K	PO-L
CO-01	S	S	M	M	L	M	M	M	L	M	M	S
CO-02	S	S	M	M	L	M	M	M	M	M	M	M
CO-03	S	S	M	M	L	M	M	M	L	M	S	S
CO-04	S	S	M	M	L	M	M	M	S	M	M	M
CO-05	S	S	M	M	L	M	M	S	S	M	S	M

S-Strong, M-Medium,L-Low,N-Not relevant

UNIT I: LINEAR ALGEBRA **9**

Vector spaces – Norms – Inner products – Eigenvalues using QR transformations — Generalized eigenvectors – Jordan Canonical forms – Singular value decomposition and applications – Pseudo inverse

UNIT II: LINEAR PROGRAMMING **9**

Formulation – Graphical solution – Simplex method: Big M Method– Transportation problems – Assignment models

UNIT III: PROBABILITY AND RANDOM VARIABLES **9**

Probability Concepts – Axioms of probability – Conditional probability – Random variables – Probability functions – Two-dimensional random variables – Joint distributions – Marginal and conditional distributions – Correlation.

UNIT IV: RANDOM PROCESSES **9**

Classification – Stationary random processes – Ergodic process - The autocorrelation – Cross Correlations – Properties - Power spectral density, Cross Power spectral density.

UNIT V: QUEUING THEORY **9**

Birth and Death process - Markovian queuing models – Little's formulae - M/M/1, M/M/C finite and infinite capacity (steady state solutions only)

L: 45 + T: 15, TOTAL: 60 HOURS

REFERENCES:

1. Friedberg A.H, Insel A.J. and Spence L, "Linear Algebra", Prentice Hall of India, New Delhi, 2004.
2. Taha, H.A., "Operations Research – An Introduction", Sixth Edition, Prentice-Hall of India, New Delhi.
3. Gupta, P.K. and Hira, D.S., "Operations Research", S.Chand& Co. New Delhi.
4. Peebles Jr., P.Z., "Probability, Random Variables and Random Signal Principles", McGraw-Hill Inc.
5. Gross, D., Shortie, J.F., Thompson, J.M and Harris, C.M., "Fundamentals of Queueing Theory", 4th Edition, Wiley, 2014.

EI4501	**ADVANCED PROCESS CONTROL**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES

- To provide in depth knowledge of controllers, find control elements and the processes.

Course Outcome		**Cognitive Skill**
CO-01	Understand the basic characteristics of first order and higher order processes	R, U
CO-02	Knowledge about the characteristics of various controller modes and methods of tuning of controller	R, U, An
CO-03	Knowledge about various complex control schemes	U, An
CO-04	Understand the characteristics and applications of various model based controllers	U, A
CO-05	Analyse the applications of PLC, SCADA and DCS in industrial process controls	An, E

R-Remember,U-Understand,A-Apply,An-Analyze,E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / **CO**	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J	PO-K	PO-L
CO-01	S	M	M	M	M	S	M	M	L	M	M	S
CO-02	S	S	S	M	M	L	M	M	M	M	M	M

CO-03	S	M	S	M	M	L	S	M	L	M	S	S
CO-04	M	S	M	S	M	M	M	M	S	M	M	M
CO-05	S	M	M	M	M	S	L	S	S	M	S	M

S-Strong, M-Medium,L-Low,N-Not relevant

UNIT I: PROCESS DYNAMICS **9**

Introduction to process control - objective of modelling - models of industrial process - hydraulic tanks - fluid flow systems - mixing process-chemical reactions - thermal systems-heat exchangers and distillation column.

UNIT II: CONTROL ACTIONS AND CONTROLLER TUNING **9**

Control Modes - Electronic PID controller – Digital PID algorithm – Auto/manual transfer - Reset windup – Pneumatic and electric actuators – Valve Positioner – Control Valves – Characteristic of Control Valves:- Inherent and Installed characteristics - Ziegler Nichols - Cohen Coon methods.

UNIT III: COMPLEX CONTROL TECHNIQUES **9**

Feed forward – ratio – cascade - split range - inferential - predictive - adaptive and multivariable control.

UNIT IV: MODEL BASED CONTROLLERS **9**

Single Varible Model Predictive Control- Introduction - Predictive Control structure - IMC Controller - Smith Predictor - Implementation Guidelines - Algorithm Selection Guidelines.

UNIT V: INDUSTRIAL PROCESS CONTROL **9**

Basic building blocks of computer control system – Interfaces –Serial, Parallel and USB Communication-Data acquisition systems – SCADA – Direct digital control Evolution of PLC – Sequential and Programmable controllers –. Evolution of DCS – DCS Architecture.

TOTAL: 45 HOURS

REFERENCES:

1. George Stephanopolus, "Chemical Process Control", Prentice Hall India
2. Harriot P., “Process Control”, Tata McGraw-Hill, New Delhi, 1991.
3. Norman A Anderson,”Instrumentation for Process Measurement and Control” CRC Press LLC, Florida, 1998.
4. Thomas E. Marlin “Process Control”, Second Edition McGraw hill, New York, 2000
5. Marlin T.E., “Process Control”, Second Edition McGraw hill, New York, 2000.
6. Balchan J.G. and Mumme G., “Process Control Structures and Applications”, Van NostrandRenhold Co., New York, 1988.
7. Lucas M.P, “Distributed Control System”, Van Nostrand Reinhold Co. NY 1986
8. Pertrezeulla, “Programmable Controllers”, McGraw-Hill, 1989.

EI4502	CONTROL SYSTEM DESIGN	L	T	P	C
		3	0	0	3

OBJECTIVES

- To provide sound knowledge in the basic concepts of linear control theory and design of control system.

Course Outcome		Cognitive Skill
CO-01	Ability to understand the fundamentals of design and classical PID control performance of system and controllers.	U
CO-02	Ability to provide adequate knowledge in state variable design.	An
CO-03	Ability to understand the design of optimal controllers.	An
CO-04	Ability to design a controller using Root-locus and Frequency Domain techniques.	A
CO-05	Ability to understand the concept of robustness and adequate case studies.	An, E

R-Remember,U-Understand,A-Apply,An-Analyze,E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J	PO-K	PO-L
CO-01	S	M	M	M	M	S	M	M	L	M	M	S
CO-02	S	S	S	M	M	L	M	M	M	M	M	M
CO-03	S	M	S	M	M	L	S	M	L	M	S	S
CO-04	M	S	M	S	M	M	M	M	S	M	M	M
CO-05	S	M	M	M	M	S	L	S	S	M	S	M

S-Strong, M-Medium,L-Low,N-Not relevant

UNIT I: INTRODUCTION TO DESIGN AND CLASSICAL PID CONTROL 9

Systems performance and specifications –Proportional, Integral and Derivative Controllers – Structure – Empirical tuning- Zeigler Nichols-Cohen Coon – Root Locus method – Open loop inversion- affine parameterisation – Tuning using ISE, IAE and other performance indices.

UNIT II: ROOT LOCUS DESIGN **9**

Design specifications in Continuous domain - Limitations- Controller structure- Multiple degrees of freedom- PID controllers and Lag-lead compensators- Root locus design- Discretization & Direct discrete design.

UNIT III: STATE VARIABLE DESIGN **9**

Design by state feedback – Output feedback – Pole assignment technique – Design of state and output feedback controllers – Design of reduced and full order observers – PI feedback – Dynamic state feedback.

UNIT IV: ROBUST CONTROL SYSTEMS **9**

H∞ and H norms .– System Sensitivity – Analysis of Robustness – Systems with uncertain Parameters – Design of Robust Control Systems –Control synthesis –loop shaping techniques.

UNIT V: CASE STUDIES **9**

Aircraft control – Control of Fuel-Air ratio in automotive engine – Control of Hard Disk Drive – Control of CSTR process – pH process.

TOTAL: 45 HOURS

REFERENCES:

1. G. C. Goodwin and etal, "Control system design', Pearson Education, 2003.
2. G. F. Franklin and etal, "Feedback Control of Dynamic Systems", Pearson Education systems, 2002.
3. Nagrath I J and Gopal M, "Control Systems Engineering", New Age International Publishers, Fifth Edition, 2008.
4. Kemin Zhou and John Doyle, "Essentials of Robust Control", Prentice-Hall Inc., 1998.
5. W. J. Granttham, T.L. Vincent, "Modern Control Systems Analysis and Design, John Wiley & Sons, 1993.
6. Gopal M, "Control Systems Principles and Design", Tata McGraw Hill Publishing Company Limited, Eighth Edition, 2008.

		L	T	P	C
EI4503	**TRANSDUCERS AND SMART INSTRUMENTS**	**3**	**0**	**0**	**3**

OBJECTIVES

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

Course Outcome		Cognitive Skill
CO-01	Ability to explain the working and characteristics of conventional transducers.	U
CO-02	Able to provide a detailed knowledge on error and determination of uncertainties in measurement.	U
CO-03	Able to give a comprehensive knowledge on smart sensor design, development and interface details.	R, U
CO-04	Exposure to manufacturing techniques and different types of Micro sensors and actuators.	An
CO-05	Exposure of latest trends in sensor technologies in industries.	A, An

R-Remember,U-Understand,A-Apply,An-Analyze,E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

(Increase or reduce the columns based on the program Outcome of the department)*

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J	PO-K	PO-L	PO-M
CO-01	S	M	M	M	M	S	M	M	L	M	M	S	
CO-02	S	S	S	M	M	L	M	M	M	M	M	M	
CO-03	S	M	S	M	M	L	S	M	L	M	S	S	
CO-04	M	S	M	S	M	M	M	M	S	M	M	M	
CO-05	S	M	M	M	M	S	L	S	S	M	S	M	

S-Strong, M-Medium,L-Low,N-Not relevant

UNIT I: OVERVIEW OF CONVENTIONAL TRANSDUCERS AND THEIR CHARACTERISTICS **9**

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

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

Importance of error analysis - Uncertainties, precision and accuracy in measurement – limiting error and probable error - Random errors - Distributions, mean, width and standard error.

Uncertainty as probability - Gaussian and Poisson probability distribution functions, confidence limits, error bars, and central limit theorem - Error propagation - single and multivariable functions, propagating error in functions.

UNIT III: SMART SENSORS **9**

Definition – Integrated smart sensors –sensing elements –design of Interface electronics - parasitic effects – sensor linearization - Dynamic range - Universal Sensor Interface – front end circuits.

DAQ – Design – Digital conversion - Microcontrollers and digital signal processors for smart sensors – selection criteria - Timer, Analog comparator, ADC and DAC modules

UNIT IV: MICRO SENSORS AND ACTUATORS **9**

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

UNIT V: RECENT TRENDS IN SENSOR TECHNOLOGIES **9**

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

TOTAL: 45 HOURS

TEXT BOOKS:

1. Ernest O Doebelin and Dhanesh N Manik, "Measurement Systems Application and Design", 5thEdition, Tata Mc-Graw Hill, 2011.
2. Ifan G. Hughes and Thomas P.A. Hase, "Measurements and their Uncertainties: A Practical Guide to Modern Error Analysis", Oxford University Press, 2010. Gerord C.M. Meijer, "Smart Sensor Systems, John Wiley and Sons, 2008.
3. Tai-Ran Hsu, "Mems and Micro Systems: Design and Manufacture, Tata McGraw Hill, 2002.
4. D. Patranabis, "Sensors and Transducers", Second Edition, PHI, 2004.

EI4571	**ADVANCED PROCESS CONTROL LABORATORY**	**L**	**T**	**P**	**C**
		0	**0**	**4**	**2**

OBJECTIVES

- To impart practical knowledge on various process control systems applied in process industries.

Course Outcome		**Cognitive Skill**
CO-01	Ability to experimentally verify the operation of interacting and non-interacting process systems.	A, An
CO-02	Ability to impart practical skill on simulation of response on-off and PID controllers.	A, An
CO-03	Ability to experimentally verify the closed loop response of several process control loops.	A, An
CO-04	Ability to simulate and experiment tuning of controllers.	A, An

CO-05	Ability to study the practical knowledge of complex control systems.	A, An

R-Remember,U-Understand,A-Apply,An-Analyze,E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J	PO-K	PO-L
CO-01	S	M	M	M	M	S	M	M	L	M	M	S
CO-02	S	S	S	M	M	L	M	M	M	M	M	M
CO-03	S	M	S	M	M	L	S	M	L	M	S	S
CO-04	M	S	M	S	M	M	M	M	S	M	M	M
CO-05	S	M	M	M	M	S	L	S	S	M	S	M

S-Strong, M-Medium,L-Low,N-Not relevant

LIST OF EXPERIMENTS:

1. Operation of interacting and non-interacting systems
2. Responses of different order processes with and without transportation lag
3. Response of on-off controller
4. Response of P+I+D controller
5. Characteristics of control valve with and without positioner
6. Operation of on-off controlled thermal process
7. Closed loop response of flow control loop
8. Closed loop response of level control loop
9. Closed loop response of temperature control loop
10. Closed loop response of pressure control loop
11. Tuning of controllers
12. Study of complex control system (ratio / cascade / feed forward).
13. Determination of characteristics of a Pneumatically Actuated Control valve (with and without Positioner)

TOTAL: 30 HOURS

SEMESTER II

SI. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	EI4504	Dynamic Control System	3	0	0	3
2.	EI4505	Process Instrument Design	3	0	0	3
3.	EI4506	Applied Industrial Instrumentation	3	0	0	3
4.	EI4507	Industrial Automation	3	0	0	3
5.	EI45**	Programme Elective II	3	0	0	3
6.	EI45**	Programme Elective III	3	0	0	3
PRACTICAL						
7.	EI4572	Automation Laboratory	0	0	4	2
TOTAL			**18**	**0**	**4**	**20**

EI4504	DYNAMIC CONTROL SYSTEM	L	T	P	C
		3	**0**	**0**	**3**

OBJECTIVES

- To educate on analysis of linear and non-linear systems and examining stability of systems.

Course Outcome		Cognitive Skill
CO-01	Understand the fundamentals of physical systems in terms of its linear and nonlinear models	U
CO-02	Understand the concept of state space representation of dynamic systems and solution techniques of state equations	U
CO-03	Perform modal analysis and design controller and observer in state space form.	An
CO-04	Identify non-linearities and analysis using describing functions.	An
CO-05	Evaluate stability of system using Lyapunov and Popov methods.	E

R-Remember,U-Understand,A-Apply,An-Analyze,E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J	PO-K	PO-L
CO-01	S	M	M	M	M	S	M	M	L	M	M	S
CO-02	S	S	S	M	M	L	M	M	M	M	M	M
CO-03	S	M	S	M	M	L	S	M	L	M	S	S
CO-04	M	S	M	S	M	M	M	M	S	M	M	M
CO-05	S	M	M	M	M	S	L	S	S	M	S	M

S-Strong, M-Medium,L-Low,N-Not relevant

UNIT I: PHYSICAL SYSTEMS AND STATE ASSIGNMENT 9

Systems: Electrical - Mechanical – Hydraulic – Pneumatic – Thermal systems –Modelling of some typical systems like DC Machines - Inverted Pendulum.

UNIT II: STATE SPACE ANALYSIS 9

Realisation of State models: – Non-uniqueness - Minimal realization – Balanced realization – Solution of state equations: – State transition matrix and its properties - Properties: Controllability and observability- Stabilisability and detectability – Kaman decomposition.

UNIT III: MODAL ANALYSIS 9

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

UNIT IV: NON-LINEAR SYSTEMS 9

Types of non-linearity – Typical examples – Equivalent linearization - Phase plane analysis – Singular points - Limit cycles – Describing functions- Analysis using Describing functions-Jump resonance.

UNIT V: STABILITY 9

Stability concepts – Equilibrium points – BIBO and asymptotic stability – Direct method of Lyapunov – Krasovskii and Variable Gradiant Method - Application to non-linear problems – Frequency domain stability criteria – Popov's method and its extensions.

TOTAL: 45 HOURS

REFERENCES:

1. M. Gopal, "Modern Control System Theory", New Age International, 2005
2. K. Ogatta, "Modern Control Engineering", PHI, 2002
3. John S. Bay, "Fundamentals of Linear State Space Systems", McGraw-Hill, 1999
4. D. Roy Choudhury, "Modern Control Systems", New Age International, 2005
5. John J. D'Azzo, C. H. Houpis and S. N. Sheldon, "Linear Control System Analysis and Design with MATLAB", Taylor Francis, 2003

6. M. Vidyasagar, “Nonlinear Systems Analysis’, 2nd edition, Prentice Hall, Englewood Cliffs, New Jersey, 2002
7. A. Nagoorkani, “Advanced Control Theory”, RBA publications, 1999

EI4505	PROCESS INSTRUMENT DESIGN	L	T	P	C
		3	0	0	3

OBJECTIVES

- To gain knowledge in the designing of process instruments.

Course Outcome		Cognitive Skill
CO-01	Ability to design signal conditioning circuits.	U, A
CO-02	Ability to design transmitters and controllers.	U, A
CO-03	Ability to design final control elements.	An
CO-04	Ability to understand the characteristics and design of control valve sizing.	An
CO-05	Ability to learn the design of alarm and annunciation circuits.	A, E

R-Remember,U-Understand,A-Apply,An-Analyze,E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J	PO-K	PO-L
CO-01	S	M	M	M	M	S	M	M	L	M	M	S
CO-02	S	S	S	M	M	L	M	M	M	M	M	M
CO-03	S	M	S	M	M	L	S	M	L	M	S	S
CO-04	M	S	M	S	M	M	M	M	S	M	M	M
CO-05	S	M	M	M	M	S	L	S	S	M	S	M

S-Strong, M-Medium,L-Low,N-Not relevant

UNIT I: DESIGN OF SIGNAL CONDITIONING CIRCUITS 9

Design of V-I, I-V, P-I and I-P converters - Analog and Digital Filter design – Signal conditioning circuit for pH measurement – Signal conditioning circuit for Temperature measurement - Cold Junction Compensation -Thermocouple Linearization.

UNIT II: DESIGN OF TRANSMITTERS 9

RTD based Temperature Transmitter – Thermocouple based Temperature Transmitter- Design of Capacitance based Level Transmitter – Air-purge Level Measurement – Design of Smart Flow Transmitters.

UNIT III: DESIGN OF DATA LOGGER AND PID CONTROLLER 9

Design of ON / OFF Controller using Linear Integrated Circuits- Electronic PID Controller – Microcontroller Based Digital PID Controller - Design of microprocessor based system for data acquisition- Micro - controller based Data Logger – Design of PC based data acquisition system.

UNIT IV: ORIFICE AND CONTROL VALVE SIZING 9

Orifice meter - design of orifice for given flow condition - design of rotameter. Design of actuators and positioners- control valves - valve characteristics - sizing of control valves - liquid, gas and steam services.

UNIT V: DESIGN OF ALARM AND ANNUNCIATION CIRCUIT 9

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

TOTAL: 45 HOURS

REFERENCES:

1. C. D. Johnson, “Process Control Instrumentation Technology”, 8th Edition, Prentice Hall, 2006.
2. Control Valve Handbook, 4th Edition, Emerson Process Management, Fisher Controls International, 2005.
3. R.W. Miller, “Flow Measurement Engineering Handbook”, Mc-Graw Hill, NewYork 1996

EI4506	APPLIED INDUSTRIAL INSTRUMENTATION	L	T	P	C
		3	0	0	3

OBJECTIVES

- To equip the students with relevant knowledge to suit the industrial requirements.

Course Outcome		Cognitive Skill
CO-01	To understand the flow meters and their installation.	U

CO-02	To remembering the measurement of various parameters.	R
CO-03	To apply air supply system in industry.	A
CO-04	To analyze the various industrial safety instrument.	An
CO-05	To acquire knowledge provided to safety instrumentation and hazards.	A

R-Remember,U-Understand,A-Apply,An-Analyze,E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J	PO-K	PO-L
CO-01	M	S	L	N	M	N	S	S	N	L	N	L
CO-02	S	M	L	S	S	S	L	S	L	N	S	S
CO-03	M	L	S	M	N	M	L	S	S	M	L	N
CO-04	S	M	L	S	S	N	L	S	M	L	M	S
CO-05	M	L	M	S	L	S	L	M	L	N	M	N

S-Strong, M-Medium,L-Low,N-Not relevant

UNIT I: SELECTION INSTALLATION OF INSTRUMENTS 9

Factors affecting for selection - Pressure Instruments - Flow Instruments- Level Instruments Temperature Instruments - Control Valve- Instrument index sheet, Loop wiring diagram, Panel drawings and specifications - Plot plans -Installation details - Checklist of good installation practices - Typical Check out procedure - Flow transmitter - Temperature transmitter - Control valve.

UNIT II: MEASUREMENT IN PETROCHEMICAL INDUSTRY 9

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

UNIT III: INSTRUMENT AIR SUPPLY SYSTEM 9

Sizing criteria and pressure level for air supply system - Supply System for low air requirement - Supply System for large air requirement - Compressor systems - Positive displacement type - Compressor controls- Dryers - Types of dryers - Refrigeration - Necessity of dryer.

UNIT IV: INSTRUMENTATION FOR INDUSTRIAL SAFETY 9

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

UNIT V: SAFETY INSTRUMENTATION 9

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

TOTAL: 45 HOURS

REFERENCES:

1. D. Patranabis, Principles of Industrial Instrumentation, Tata MCGraw Hill, 2020.
2. Donald P. Eckman, Industrial Instrumentation, Wiley Eastern Limited, 2019.
3. John P. Bentely, Principles of Measurement System, Longman Scientific and Technical, 2015.
4. Jone's, Instrument Technology, Vol. 1: Mechanical Measurements, English Language Book Society, Fourth Edition, 2018.
5. Douglas M. Considine, Editor-in-Chief, Process Instruments and Controls Handbook, Fourth Edition, McGraw-Hill Book Co., 1994
6. Doebelin, E.O., Measurement Systems, McGraw Hill, Fourth edition, Singapore, 2020.
7. R.K. Jain, Mechanical and Industrial measurements, Khanna publishers, Delhi, 2019.
8. Paul Gruhn, P.E., CFSE and Harry Cheddie, P.E., "Safety Instrumented Systems: Design, Analysis, and Justification", 2nd Edition, ISA, 2016.

EI4507	INDUSTRIAL AUTOMATION	L	T	P	C
		3	0	0	3

OBJECTIVES

- To introduce the importance of automation techniques in manufacturing and process industries.
- Study of components used in data acquisition systems interface techniques.
- To expose to various control techniques employed in process automation.

Course Outcome		Cognitive Skill
CO-01	Ability to be familiar with various automation technologies in manufacturing and process industries.	U
CO-02	Ability to design signal conditioning circuits for industrial automation.	U, A
CO-03	Ability to acquire detail knowledge on data acquisition system interface and DCS system.	A
CO-04	Ability to impart the role of PLC in industry automation.	An

CO-05	Ability to identify the difference between SCADA and DCS applied in automation industries.	A

R-Remember,U-Understand,A-Apply,An-Analyze,E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J	PO-K	PO-L
CO-01	M	S	L	N	M	N	S	S	N	L	N	L
CO-02	S	M	L	S	S	S	L	S	L	N	S	S
CO-03	M	L	S	M	N	M	L	S	S	M	L	N
CO-04	S	M	L	S	S	N	L	S	M	L	M	S
CO-05	M	L	M	S	L	S	L	M	L	N	M	N

S-Strong, M-Medium,L-Low,N-Not relevant

UNIT I: AUTOMATION OVERVIEW **9**

Introduction- Automation in production system, Principles and strategies of automation, Basic elements of an automated system, Advanced automation functions, Levels of automations, Automated flow lines and transfer mechanisms, Analysis of transfer lines without storage, Automated flow lines with storage buffers.

UNIT II: AUTOMATION COMPONENTS **9**

Sensors for temperature, pressure, force, displacement, speed, flow, level, humidity and pH measurement. Actuators, process control valves, power electronics devices DIAC, TRIAC, power MOSFET and IGBT. Introduction of DC and AC servo drives for motion control.

UNIT III: COMPUTER AIDED MEASUREMENT & CONTROL SYSTEMS **9**

Role of computers in measurement and control, Elements of computer aided measurement and control, man-machine interface, computer aided process control hardware, process related interfaces, Communication and networking, Industrial communication systems, Data transfer techniques, Computer aided process control software, and Computer based data acquisition system, Internet of things (IoT) for plant automation.

UNIT IV: PROGRAMMABLE LOGIC CONTROLLERS **9**

Programmable Logic Controller (PLC)- Block diagram of PLC, Programming languages of PLC, Basic instruction sets, Design of alarm and interlocks, Networking of PLC, Overview of safety of PLC with case studies. Process Safety Automation: Levels of process safety through use of PLCs, Integrating Process safety PLC and DCS, Application of international standards in process safety control.

UNIT IV: SCADA AND DISTRIBUTED CONTROL SYSTEM **9**

Introduction to computer based industrial automation- Direct Digital Control (DDC), Distributed Control System (DCS) - Local Control Unit (LCU) architecture, LCU Process Interfacing Issues, Block diagram and Overview of different LCU security design

approaches. Supervisory control and data acquisition (SCADA) based architectures- SCADA for process industries includes understanding of RTUs, Pumping stations, Evacuation processes, Transport Automation.

TOTAL: 45 HOURS

REFERENCES:

1. S. K. Singh, "Industrial Instrumentation", Tata McGraw Hill, 2nd edition companies, 2003.
2. C D Johnson, "Process Control Instrumentation Technology", Prentice Hall India, 8th Edition, 2006.
3. E. A. Parr, Newnes, New Delhi, "Industrial Control Handbook", 3rd Edition, 2000.
4. Gary Dunning, Thomson Delmar, "Programmable Logic Controller", Cengage Learning, 3rd Edition, 2005.
5. Krishna Kant, "Computer - Based Industrial Control", 2nd Edition, Prentice Hall, New Delhi, 2011.
6. Frank D. Petruzella, "Programmable Logic Controllers", 5th Edition, McGraw- Hill, New York, 2016.
7. Lukas M.P, "Distributed Control Systems", Van Nostrand Reinhold Co., New York, 1986

EI4572	**AUTOMATION LABORATORY**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES

- To teach the importance of monitoring, control and impart skills in automation.

Course Outcome		**Cognitive Skill**
CO-01	Interpretation of Piping & Instrumentation Diagrams.	U
CO-02	Developing control strategies using functional blocks in DCS.	U
CO-03	Interfacing pilot plants with Industrial Type Distributed Control System.	An
CO-04	Programming of Industrial Type Programmable Logic Controller	An
CO-05	Design and implementation of advanced control schemes.	An

R-Remember,U-Understand,A-Apply,An-Analyze,E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J	PO-K	PO-L
CO-01	S	M	M	M	M	S	M	M	M	M	M	S
CO-02	S	S	S	M	M	M	M	M	M	M	M	M
CO-03	S	M	S	M	M	M	S	M	M	M	S	S
CO-04	M	S	M	S	M	M	M	M	S	M	M	M
CO-05	S	M	M	M	M	S	M	S	S	M	S	M

S-Strong, M-Medium,L-Low,N-Not relevant

LIST OF EXPERIMENTS

1. Interpretation of P & ID
2. Control of a typical process using multi-loop PID controller.
3. Interfacing data acquisition card with personal computer.
4. Programming jump-to-subroutine & return operations in PLC.
5. Simulation of traffic light control using ladder logic.
6. PC based control of level process.
7. Develop feedback and cascade control strategies using Function Blocks in DCS.
8. On-line monitoring and control of a plant using an industrial type DCS.
9. Simple exercises using the Instruction Set of Programmable Logic Controller.
10. Programmable logic controller exercises for Filling / Draining control operation
11. Programmable logic controller exercises for Reversal of dc motor direction
12. Control of level and flow measurement system using industrial type PLC.

TOTAL: 30 HOURS

ELECTIVES

SI. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
1.	EI45A1	Applied Bio-Medical Instrumentation	3	0	0	3
2.	EI45A2	Piping and Instrumentation Design	3	0	0	3
3.	EI45A3	Robotics and Automation	3	0	0	3
4.	EI45A4	Design of Embedded Systems	3	0	0	3
5.	EI45A5	Modeling and Simulation	3	0	0	3
6.	EI45A6	Bio Medical Signal Processing	3	0	0	3
7.	EI45A7	Internet of Things and Applications	3	0	0	3
8.	EI45A8	Advanced Digital Signal Processing	3	0	0	3
9.	EI45A9	Intelligent Control Techniques	3	0	0	3
10.	EI45B1	Digital Instrumentation	3	0	0	3
11.	EI45B2	Wireless Sensor Networks	3	0	0	3
12.	EI45B3	Industrial Data Communication	3	0	0	3
13.	EI45B4	Smart Grid	3	0	0	3

EI45A1	APPIED BIOMEDICAL INSTRUMENTATION	L	T	P	C
		3	0	0	3

OBJECTIVES

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

Course Outcome		Cognitive Skill
CO-01	Ability to apply fundamental principles for designing and modelling biomedical systems.	U
CO-02	Ability to use mathematical/computational tools for biomedical image and signal analysis.	U
CO-03	Ability to learn about acquisition of biological signals and their analysis in biomedical measurements.	U
CO-04	Ability to acquire knowledge on biomedical instrumentation and their applications in monitoring and analysis.	An

CO-05	Ability to learn biomedical implants and microsystems and their clinical applications.	An

R-Remember,U-Understand,A-Apply,An-Analyze,E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J	PO-K	PO-L
CO-01	S	M	M	M	M	S	M	M	M	M	M	S
CO-02	S	S	S	M	M	M	M	M	M	M	M	M
CO-03	S	M	S	M	M	M	S	M	M	M	S	S
CO-04	M	S	M	S	M	M	M	M	S	M	M	M
CO-05	S	M	M	M	M	S	M	S	S	M	S	M

S-Strong, M-Medium,L-Low,N-Not relevant

UNIT I: INTRODUCTION TO BIOMEDICAL MEASUREMENTS 9

Physiological systems and measurable variables- Nature and complexities of biomedical measurements- Medical equipment standards and safety- Biocompatibility - Human and Equipment safety – Physiological effects of electricity, Micro and macro shocks, thermal effects. Recent trends and developments in Medical Instruments and techniques.

UNIT II: BIOMEDICAL SIGNALS AND THEIR ACQUISITIONS 9

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

UNIT III: INSTRUMENTATION FOR DIAGNOSIS AND MONITORING 9

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

UNIT IV: BIOMEDICAL IMPLANTS AND MICROSYSTEMS 9

Implantable medical devices: artificial valves, vascular grafts and artificial joints- cochlear implants - cardiac pacemakers – Microfabriation technologies for biomedical Microsystems-microsensors for clinical applications - Sensing and transfer of data in telemedicine, Telemedicine standards, Mobile telemedicine, Internet applications in telemedicine

UNIT V: LASER AND PHOTONICS **9**

Laser: Principle, Materials and Types, Future of medical lasers and fiber optics. Diagnostic applications of lasers - Ophthalmology, Dentistry, Urology, Neurosurgery, Dermatology, Orthopedics, Angioplasty, Cardiology, and Surgery diffused optical tomography.

Biomedical Photonics: Optical property of tissue, Light-tissue interaction, basic instrumentation in photonics, biomedical diagnosis, Lasers for biophotonics: Intervention and Treatment techniques.

TOTAL: 45 HOURS

REFERENCE BOOKS:

1. John G.Webster, "Bioinstrumentation", John Wiley & Sons, 2008.
2. Shayne C.Gad, "Safety Evaluation of Medical Devices", CRC Press, Second Edition, 2002.
3. Michael C.K.Khoo, "Physiological Control Systems: Analysis, Simulation and Estimation", IEEE Press, 2000.
4. John G.Webster, "Medical Instrumentation Application and Design", John Wiley & Sons, Third Edition, 2009.
5. Markolf H. Niemz, "Laser-Tissue Interactions: Fundamentals and Applications", Third edition, Springer 2007.
6. Thyagarajan K, Ajoy K, Ghatak A, "Lasers Fundamentals and Applications, Second edition", Springer 2010

EI45A2	**PIPING AND INSTRUMENTATION DESIGN**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES

- Focuses on engineering drawings typically used in the chemical and process industries by engineers and technologists in the design phase, and by operations and maintenance staff once facilities are up and running.

Course Outcome		**Cognitive Skill**
CO-01	Ability to gain knowledge on fundamentals of piping engineering, pipe hydraulics, piping supports and instrumentation.	U
CO-02	Ability to effectively assess emergency situations and evaluate safety, environmental, and regulatory compliance issues in industries.	U
CO-03	Ability to create accurate drawings and the ability to interpret them.	U
CO-04	Ability to explore knowledge on piping technology and instrumentation on pipelines.	An

CO-05	Ability to focus on critical documentation essential to the safe day-to-day operation in instrumentation.	An

R-Remember,U-Understand,A-Apply,An-Analyze,E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J	PO-K	PO-L
CO-01	S	M	M	M	M	S	M	M	M	M	M	S
CO-02	S	S	S	M	M	M	M	M	M	M	M	M
CO-03	S	M	S	M	M	M	S	M	M	M	S	S
CO-04	M	S	M	S	M	M	M	M	S	M	M	M
CO-05	S	M	M	M	M	S	M	S	S	M	S	M

S-Strong, M-Medium,L-Low,N-Not relevant

UNIT I: FLOW SHEETS **9**

Types of flow sheets, Flow sheet Presentation, Flow Sheet Symbols, introduction to process flow diagram (PFD) and piping and instrumentation diagram (P&ID), Synthesis of steady state flow sheet - Flow sheeting software.

UNIT I: INTRODUCTION TO PLANT DESIGN **9**

Piping Introduction, A Typical Plant Design Project, Plant Layout, Process Flow Diagram, Piping and Instrumentation Diagrams, Piping Layouts, Flow sheet Presentation.

UNIT II: P & ID SYMBOLS AND SPECIFICATIONS **9**

P&ID's, Piping and Equipment Designations and Symbols, Instrumentation Designations and Symbols, Piping Line Lists- guide rules - Piping Documentation - Piping Specifications

UNIT III: PIPE SUPPORTS AND P & ID **9**

Pipe Supporting Systems, Recommended Pipe Spans, Pipe Spacing, Pipe Shoes, Base Ells and Dummy Legs, Pipe Guides, Pipe Restraints (Limit Stops), Rod Hangers, Variable Spring Hangers, Constant Load Hangers.

P & ID for rotating equipment and static pressure vessels, Process vessels, absorber, evaporator.

UNIT IV: CONTROL SYSTEM DEVELOPMENT **9**

Control System for Heater, Heat exchangers, reactors, dryers, Distillation column, Expander, Level, Temperature, Flow and Level process.

UNIT V: APPLICATIONS OF P & ID **9**

Applications of P & ID in design stage - Construction stage - Commissioning stage - Operating stage - Revamping stage - Applications of P & ID in HAZOPS and Risk analysis.

TOTAL = 45 HOURS

REFERENCES:

1. Ernest E. Ludwig, "Applied Process Design for Chemical and Petrochemical Plants", Vol.-I Gulf Publishing Company, Houston, 1989.
2. Max. S. Peters and K. D. Timmerhaus, "Plant Design and Economics for Chemical Engineers", McGraw Hill, Inc., New York, 1991.
3. Anil Kumar, "Chemical Process Synthesis and Engineering Design", Tata McGraw Hill publishing Company Limited, New Delhi - 1981.
4. A. N. Westerberg, et al., "Process Flow sheeting", Cambridge University Press, 1979

EI45A3	ROBOTICS AND AUTOMATION	L	T	P	C
		3	0	0	3

OBJECTIVES

- To introduce the concepts of Robotic system, its components and instrumentation and control related to robotics.

Course Outcome		Cognitive Skill
CO-01	Able to understand the components and basic terminology of robotics.	U
CO-02	Able to understand the motion of robots and analyze the workspace.	U
CO-03	Ability to apply the dynamic modelling of the robot.	U
CO-04	Able to analyze the planning of manipulator trajectories.	An
CO-05	Able to acquire knowledge the control of robot manipulators	An

R-Remember,U-Understand,A-Apply,An-Analyze,E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J	PO-K	PO-L
CO-01	S	M	L	S	S	S	L	S	S	L	S	L
CO-02	M	L	M	S	L	M	L	S	N	L	S	N
CO-03	M	S	L	N	M	N	S	S	N	L	N	L
CO-04	S	M	L	S	S	S	L	S	L	N	S	S
CO-05	M	M	S	S	L	N	L	S	S	L	L	S

S-Strong, M-Medium,L-Low,N-Not relevant

UNIT I: INTRODUCTION **9**

Geometric configuration of robots – Manipulators – Drive systems – Internal and external sensors – End effectors – Control systems – Robot programming languages and applications – Introduction to robotic vision.

UNIT II: ROBOT ARM KINEMATICS **9**

Direct and inverse kinematics – Rotation matrices – Composite rotation matrices – Euler angle representation – Homogenous transformation – Denavit Hattenberg representation and various arm configuration.

UNIT III: ROBOT ARM DYNAMICS **9**

Lagrange – Euler formulation, joint velocities – Kinetic energy – Potential energy and motion equations – Generalised D'Alembert equations of motion.

UNIT IV: PLANNING OF MANIPULATOR TRAJECTORIES **9**

General consideration on trajectory planning joint interpolation & Cartesian path trajectories - Robot programming languages and applications.

UNIT V: CONTROL OF ROBOT MANIPULATORS **9**

PID control computed, torque technique – Near minimum time control – Variable structure control – Non-linear decoupled feedback control – Resolved motion control and adaptive control.

TOTAL: 45 HOURS

REFERENCES:

1. Fu, K.S. Gonazlez, R.C. and Lee, C.S.G., "Robotics (Control, Sensing, Vision and Intelligence), McGraw-Hill, 1968 (II printing).
2. Wesley, E. Sryda, "Industrial Robots: Computer interfacing and Control" PHI, 1985.
3. Asada and Slotine, "Robot Analysis and Control", John Wiley and Sons, 1986.
4. Philippe Coiffet, "Robot Technology" Vol. II (Modelling and Control), Prentice Hall INC, 1981.
5. Saeed B. Niku, "Introduction to Robotics, Analysis, systems and Applications", Pearson Education, 2002

EI45A4	**DESIGN OF EMBEDDED SYSTEMS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES

- The objective of this course is to enable the students to understand embedded-system and apply that knowledge to design and develop embedded solutions.

Course Outcome		**Cognitive Skill**
CO-01	Ability to develop the hardware for embedded system application based on the processors.	U
CO-02	Ability to discuss on embedded networking and communication protocols.	U

CO-03	Ability to explore the features of RTOS based embedded system and provide apt solutions for any embedded application.	U
CO-04	Ability to explore the skills of software development tools in building real time embedded systems.	An
CO-05	Ability to learn the features of embedded system application development tool to develop any real time embedded application.	An

R-Remember,U-Understand,A-Apply,An-Analyze,E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J	PO-K	PO-L
CO-01	S	M	L	S	S	S	L	S	S	L	S	L
CO-02	M	L	M	S	L	M	L	S	N	L	S	N
CO-03	M	S	L	N	M	N	S	S	N	L	N	L
CO-04	S	M	L	S	S	S	L	S	L	N	S	S
CO-05	M	M	S	S	L	N	L	S	S	L	L	S

S-Strong, M-Medium,L-Low,N-Not relevant

UNIT I: INTRODUCTION TO EMBEDDED SYSTEMS **9**

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

UNIT II: EMBEDDED NETWORKING **9**

Embedded Networking: Introduction, I/O Device Ports & Buses– Serial Bus communication protocols - RS232 standard – RS485 – USB – Inter Integrated Circuits (I^2C) – interrupt sources , Programmed-I/O busy-wait approach without interrupt service mechanism- ISR concept-– multiple interrupts – Wireless protocol based on Wifi, Bluetooth, Zigbee – Introduction to Device Drivers.

UNIT III: RTOS **9**

Introduction to RTOS- Task, process & threads, interrupt routines in RTOS, Multiprocessing and Multitasking, Pre-emptive and non-pre-emptive scheduling, Task communication- shared memory, message passing-, Interprocess Communication – synchronization between processes-semaphores, Mailbox, pipes, priority inversion, priority inheritance-comparison of commercial RTOS features -RTOS Lite, Full RTOS.

UNIT IV: DEVELOPMENT TOOLS **9**

Software Development environment-IDE, assembler, compiler, linker, simulator, debugger, Incircuit emulator, Target Hardware Debugging, need for Hardware-Software Partitioning and Co-Design.

Overview of UML, Scope of UML modeling, Conceptual model of UML, Architectural, UML basic elements.

UNIT V: EMBEDDED SYSTEM APPLICATION DEVELOPMENT **9**

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

TOTAL: 45 HOURS

REFERENCES:

1. Rajkamal, 'Embedded system-Architecture, Programming, Design', TMH, 2011.
2. Peckol, "Embedded system Design", John Wiley &Sons, 2010
3. Shibu. K. V, "Introduction to Embedded Systems", Tata McGraw Hill, 2009
4. Lyla B Das," Embedded Systems-An Integrated Approach", Pearson2013
5. Tammy Noergaard,"Embedded System Architecture, A comprehensive Guide for Engineers and Programmers", Elsevier, 2006

EI45A5	**MODELING AND SIMULATION**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES

- To study the modeling and simulation techniques of chemical processes and to gain skills in using process simulators.

Course Outcome		**Cognitive Skill**
CO-01	Ability to analyse and model physical and chemical phenomena involved in various processes.	U, An
CO-02	Ability to develop mathematical models for various control processes.	U, S
CO-03	Ability to apply various simulation approaches.	U, A
CO-04	Ability to model simple systems and complex systems.	An
CO-05	Ability to solve engineering problems and to simulate the solution.	An

R-Remember,U-Understand,A-Apply,An-Analyze,E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J	PO-K	PO-L
CO-01	S	M	L	S	S	S	L	S	S	L	S	L
CO-02	M	L	M	S	L	M	L	S	N	L	S	N
CO-03	M	S	L	N	M	N	S	S	N	L	N	L
CO-04	S	M	L	S	S	S	L	S	L	N	S	S
CO-05	M	M	S	S	L	N	L	S	S	L	L	S

S-Strong, M-Medium,L-Low,N-Not relevant

UNIT I: OVERVIEW OF MATHEMATICAL MODELING 9

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

UNIT II: SIMPLE SYSTEM MODEL DEVELOPMENT 9

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

UNIT III: COMPLEX SYSTEM MODEL DEVELOPMENT 9

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

UNIT IV: NUMERICAL SOLUTIONS OF MODEL EQUATIONS 9

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

UNIT V: STRATEGIES FOR DISTRIBUTED PARAMETER MODELS 9

Solution strategies for distributed parameter models. Solving parabolic, elliptic and hyperbolic partial differential equations. Finite element and finite volume methods.

TOTAL: 45 HOURS

REFERENCES:

1. Bequette, B.W., "Process Dynamics: Modeling, Analysis and Simulation, Prentice-Hall International", Singapore, 1998.
2. Jana, A.K. "Chemical Process Modeling and Computer simulation", Prentice-Hall-India, New Delhi, 2011,
3. Finlayson, B.A., "Introduction to Chemical Engineering Computing", Wiley Student Edition, Singapore, 2006.
4. M.Chidambaram, "Mathematical Modeling and Simulation for Engineers", Cambridge University Press, New Delhi -2017

EI45A6	BIO MEDICAL SIGNAL PROCESSING	L	T	P	C
		3	0	0	3

OBJECTIVES

- To introduce fundamental, theoretical and methodological principles of biosignal processing and analysis.

Course Outcome		Cognitive Skill
CO-01	Ability to provide information to physicians and allows them to make a diagnosis.	R
CO-02	Ability to explore both theoretical and methodological principles of biosignal processing and analysis.	R, U
CO-03	Ability to estimate parametric models of the measured biosignals for prediction, simulation and diagnostic purposes.	U, A
CO-04	Ability to estimate suitable models of the measured bio signals.	A
CO-05	Ability to use mathematical/computational tools for biomedical image and signal analysis.	An

R-Remember,U-Understand,A-Apply,An-Analyze,E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J	PO-K	PO-L
CO-01	S	L	L	M	M	L	L	M	L	L	L	S
CO-02	M	S	M	M	M	L	M	L	M	S	S	M
CO-03	M	M	S	S	M	M	L	S	S	M	L	M
CO-04	M	M	L	L	S	S	S	M	L	M	M	L
CO-05	L	L	M	L	S	L	S	L	L	M	M	L

S-Strong, M-Medium,L-Low,N-Not relevant

UNIT I: INTRODUCTION TO SIGNALS **9**

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

UNIT II: CLASSICAL SPECTRAL ESTIMATION TECHNIQUES 9

Periodogram, Blackman – Tukey spectral Estimation - Analysis of the biosignal using Periodogram,–Cepstra, power cepstrum, applications of cepstrum analysis – analysis of the biosignal using cepstrum technique.

UNIT III: ADAPTIVE NOISE CANCELLATION 9

Introduction, principle of Adaptive Noise Cancelling(ANC), - Adaptive Noise cancellation with the LMS and RLS algorithm - Applications.

UNIT IV: PARAMETRIC MODELING METHODS 9

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

UNIT V: CLUSTERING AND WAVELET TRANSFORM FOR BIOSIGNAL PROCESSING 9

Clustering methods – hard and fuzzy clustering, applications of Fuzzy clustering to Biomedical signal processing, Wavelet transform – Introduction, Filter bank implementation of discrete wavelet transform, signal Denoising using wavelet transform, wavelet based compression.

TOTAL: 45 HOURS

REFERENCES:

1. M.Akay, "Biomedical Signal Processing", Academic Press, San Diego, 1994.
2. M.Akay, "Nonlinear Biomedical Signal Processing", Fuzzy Logic, Neural Networks and New Algorithms, vol.1, IEEE Press Series on Biomedical Engineering, New York, 2000.
3. Eugene N.Bruce, "Biomedical Signal Processing and Signal Modeling", John Wiley & Sons, First Edition, 2000G.

EI45A7	INTERNET OF THINGS AND APPLICATIONS	L	T	P	C
		3	0	0	3

OBJECTIVES

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

Course Outcome		Cognitive Skill
CO-01	Ability to gain knowledge about the principles of Internet.	R

CO-02	Ability to control and monitor all the processes taking place at remote location.	R, U
CO-03	Ability to provide an insight into Design and Development of IOT application.	A
CO-04	Ability to realize an IoT application	A, An
CO-05	Ability to learn the use of IoT in different applications.	An

R-Remember,U-Understand,A-Apply,An-Analyze,E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J	PO-K	PO-L
CO-01	S	L	L	M	M	L	L	M	L	L	L	S
CO-02	M	S	M	M	M	L	M	L	M	S	S	M
CO-03	M	M	S	S	M	M	L	S	S	M	L	M
CO-04	M	M	L	L	S	S	S	M	L	M	M	L
CO-05	L	L	M	L	S	L	S	L	L	M	M	L

S-Strong, M-Medium,L-Low,N-Not relevant

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.

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 .

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 : DIGITAL TWIN **9**

DIGITAL TWIN: Introduction to Digital Twin, need for Digital Twin, Elements of Digital Twin, Digital Twin process design and information requirements, Digital twin conceptual architecture -create, communicate, Aggregate, Analyze, Insight, Act, driving business value through digital twin.

DIGITAL TWIN FOR ASSET: Digitalizing asset behaviour using simulated mathematical modelling and building Digital Twin -Need, Benefits, Architecture, Models and Use cases - Predictive and Prescriptive maintenance.

TOTAL: 45 HOURS

REFERENCES:

1. ArshdeepBahga and Vijay Madisetti, “Internet of Things A Hands-on Approach”, Universities Press (India), 2015.
2. Alasdair Gilchrist," Industry 4.0: The Industrial Internet of Things”, A press, 2016.
3. Adrian McEwen and Hakim Cassimally, “Designing the Internet of Things”, John Wiley & Sons, 2014.
4. Beheshti, S. M. R., Benatallah, B., Sakr, S., "Process Analytics Concepts and Techniques for Querying and Analyzing Process Data" Springer International Publishing Switzerland, 2016

EI45A8	ADVANCED DIGITAL SIGNAL PROCESSING	L	T	P	C
		3	0	0	3

OBJECTIVES

- To introduce the concept of analyzing discrete time signals & systems in the time and frequency domain.

Course Outcome		Cognitive Skill
CO-01	Students will learn the essential advanced topics in DSP that are necessary for successful Postgraduate level research. Also Students will have the ability to solve various types of practical problems in DSP.	R, A
CO-02	Comprehend the DFTs and FFTs, design and Analyze the digital filters, comprehend the Finite word length effects in Fixed point DSP Systems.	U, A
CO-03	The conceptual aspects of Signal processing Transforms are introduced.	U, A
CO-04	The comparison on commercial available DSProcessors helps to understand system design through processor interface.	A
CO-05	Improved Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in embedded systems design.	An

R-Remember,U-Understand,A-Apply,An-Analyze,E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J	PO-K	PO-L
CO-01	S	S	M	M	M	S	L	M	L	L	L	S
CO-02	S	S	M	S	S	L	M	S	M	S	S	M
CO-03	M	S	S	S	L	M	M	L	S	S	L	S
CO-04	M	M	L	M	S	S	S	M	S	M	S	L
CO-05	L	L	M	L	S	L	S	L	L	S	M	L

S-Strong, M-Medium,L-Low,N-Not relevant

UNIT I: DISCRETE TIME SIGNALS AND SYSTEMS 9

Representation of discrete time signal – classifications – Discrete time – system – Basic operations on sequence – linear – Time invariant – causal – stable – solution to difference equation – convolution sum – correlation – Discrete time Fourier series – Discrete time Fourier transform.

UNIT II: TRANSFORMS AND PROPERTIES 9

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

UNIT III: ADAPTIVE FILTERS 9

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

UNIT IV: ARCHITECTURE OF COMMERCIAL DIGITAL SIGNAL PROCESSORS 9

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

UNIT V: INTERFACING I/O PERIPHERALS FOR DSP BASED APPLICATIONS 9

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

TOTAL: 45 HOURS

REFERENCES:

1. John. G. Proakis, Dimitris G. Manolakis, "Digital signal processing", Pearson Edu, 2002.
2. Sen M.Kuo,Woon-Seng S.Gan, "Digital Signal Processors- Pearson Edu, 2012
3. Robert J.Schilling, Sandra L.Harris,"Introd. To Digital Signal Processing with Matlab", Cengage, 2014.
4. Steven A. Tretter, "Communication System Design Using DSP Algorithms with Laboratory Experiments for the TMS320C6713™ DSK", Springer, 2008.
5. Rulph Chassaing and Donald Reay, "Digital Signal Processing and Applications with the TMS320C6713 and TMS320C6416 DSK", John Wiley & Sons, Inc., Hoboken, New Jersey, 2008.
6. K.P. Soman and K.L. Ramchandran, Insight into WAVELETS from theory to practice, Eastern Economy Edition, 2008
7. B Venkataramani and M Bhaskar "Digital Signal Processors", TMH, 2nd, 2010
8. Vinay K.Ingle,John G.Proakis,"DSP-A Matlab Based Approach",Cengage Learning,2010
9. Taan S.Elali,"Discrete Systems and Digital Signal Processing with Matlab",CRC Press2009.
10. Avatar Sing, S. Srinivasan, "Digital Signal Processing- Implementation using DSP Microprocessors with Examples from TMS320C54xx", Thomson India,2004.

EI45A9	**INTELLIGENT CONTROL TECHNIQUES**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES

- To expose the concepts of intelligent systems and provide adequate knowledge about neural networks.
- To teach about the concept of fuzziness, genetic algorithm and hybrid techniques.

Course Outcome		**Cognitive Skill**
CO-01	Ability to understand the intelligent agents and search methods.	R, A
CO-02	Ability to know about neural networks and its application in control.	U, A
CO-03	Ability to apply genetic algorithm for optimisation problems.	U
CO-04	Understand the role of fuzzy logic system.	U
CO-05	Ability to design applications.	A

R-Remember,U-Understand,A-Apply,An-Analyze,E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J	PO-K	PO-L
CO-01	S	L	M	L	L	L	S	S	S	M	M	M
CO-02	L	M	S	M	S	S	M	S	S	M	S	S
CO-03	M	M	L	S	S	L	S	M	S	S	S	L
CO-04	S	S	M	S	M	S	L	M	M	L	M	S
CO-05	L	S	L	L	S	M	L	L	L	M	L	S

S-Strong, M-Medium,L-Low,N-Not relevant

UNIT I: INTRODUCTION **9**

Approaches to intelligent control. Architecture for intelligent control, Symbolic reasoning system, rule-based systems, the AI approach. Knowledge representation, Expert systems.

UNIT II: ARTIFICIAL NEURAL NETWORKS **9**

Concept of Artificial Neural Networks and its basic mathematical model, McCulloch-Pitts neuron model, simple perceptron, Adaline and Madaline, Feed-forward Multilayer Perceptron. Learning and Training the neural network, Hopfield network, Self-organizing network and Recurrent network, Neural Network based controller.

UNIT III: FUZZY LOGIC SYSTEM **9**

Introduction to crisp sets and fuzzy sets, basic fuzzy set operation and approximate reasoning, Introduction to fuzzy logic modeling and control, Fuzzification, inferencing and defuzzification, Fuzzy knowledge and rule bases, Fuzzy modeling and control schemes for nonlinear systems.

UNIT IV: GENETIC ALGORITHM& PARTICLE SWARM **9**

Basic concept of Genetic algorithm and detail algorithmic steps, adjustment of free parameters, Solution of typical control problems using genetic algorithm, Particle swarm optimisation –principle and theory.

UNIT V: APPLICATIONS **9**

Design of controllers using Neural Networks, Fuzzy Logic and GA for Inverted Pendulum and Heat Exchanger process.

TOTAL: 45 HOURS

REFERENCES:

1. Jacek. M. Zurada, "Introduction to Artificial Neural Systems", Jaico Publishing House, 1999.
2. KOSKO,B. "Neural Networks And Fuzzy Systems", Prentice-Hall of India Pvt. Ltd., 1994.
3. KLIR G.J. & FOLGER T.A. "Fuzzy sets, uncertainty and Information", Prentice-Hall of India Pvt. Ltd., 1993.

4. Zimmerman H.J. "Fuzzy set theory-and its Applications"-Kluwer Academic Publishers, 1994.
5. Driankov, Hellendroon, "Introduction to Fuzzy Control", Narosa Publishers

EI45B1	DIGITAL INSTRUMENTATION	L	T	P	C
		3	0	0	3

OBJECTIVES

- To understand the fundamentals building blocks of a digital instrument
- To learn about the different digital data communication techniques
- To study on bus communication standards and working principles
- To learn graphical programming for instrument building

Course Outcome		Cognitive Skill
CO-01	Ability to understand the need for data acquisition systems	U
CO-02	Perform computational and measurement activities using digital techniques	U, A
CO-03	Ability to learn the different communication standards	U
CO-04	Able to make of use of graphical programming languages for instrument building.	A
CO-05	To discuss on different case studies.	A, An

R-Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J	PO-K	PO-L
CO-01	S	L	M	L	L	L	S	S	S	M	M	M
CO-02	L	M	S	M	S	S	M	S	S	M	S	S
CO-03	M	M	L	S	S	L	S	M	S	S	S	L
CO-04	S	S	M	S	M	S	L	M	M	L	M	S
CO-05	L	S	L	L	S	M	L	L	L	M	L	S

S-Strong, M-Medium ,L-Low, N-Not relevant

UNIT I: DATA ACQUISITION SYSTEMS **9**

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

UNIT II: INSTRUMENT COMMUNICATION **9**

Introduction, Modem standards, Data transmission systems- Time Division Multiplexing (TDM) – Digital Modulation Basic requirements of Instrument Bus Communications standards, interrupt and data handshaking , serial bus- basics, Message transfer, - RS-232, USB, RS-422, Ethernet Bus- CAN standards interfaces . HART network, Mod Bus, Fieldbus.

UNIT III: VIRTUAL INSTRUMENTATION BASICS **9**

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

UNIT IV: PROGRAMMABLE INSTRUMENTATION **9**

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

UNIT V: CASE STUDIES **9**

PC based DAS, Data loggers; PC based industrial process measurements like flow, temperature, pressure and level development system, CRT interface and controller with monochrome and color video display.

TOTAL: 45 HOURS

REFERENCES:

1. Mathivanan, “PC based Instrumentation Concepts and practice”, Prentice-Hall India, 2009
2. Jovitha Jerome, “Virtual Instrumentation using Labview”, PHI, 2010.
3. Jonathan W Valvano, “Embedded Microcomputer systems”, Brooks/Cole, Thomson, 2010.
4. Cory L.Clark,”Labview Digital Signal Processing & Digital Communication, TMcH, 2005
5. Lisa K. wells & Jeffrey Travis, Lab VIEW for everyone, Prentice Hall, New Jersey, 1997.
6. H S Kalsi, “Electronic Instrumentation” Second Edition, Tata McGraw-Hill, 2006.
7. Gary Johnson, LabVIEW Graphical Programming, Second edition, McGHill, Newyork, 1997

EI45B2	WIRELESS SENSOR NETWORKS	L	T	P	C
		3	0	0	3

OBJECTIVES

- To introduce the technologies and applications of wireless sensor networks.
- To understand the various layers in the WSN protocol stack.
- To learn about the MAC protocols.
- To learn about the Routing protocols
- To familiarize the students with the platforms used in the design of WSN

Course Outcome		Cognitive Skill
CO-01	Ability to explain common wireless sensor node architectures.	U
CO-02	Ability to carry out simple analysis and planning of WSNs.	U, A
CO-03	Ability to demonstrate knowledge of MAC protocols developed for WSN.	U
CO-04	Ability to demonstrate knowledge of routing protocols developed for WSN.	A
CO-05	Ability to understand and explain the design methodology of WSN and its applications.	A, An

R-Remember,U-Understand,A-Apply,An-Analyze,E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J	PO-K	PO-L	PO-M
CO-01	S	L	M	L	L	L	S	S	S	M	M	M	S
CO-02	L	M	S	M	S	S	M	S	S	M	S	S	L
CO-03	M	M	L	S	S	L	S	M	S	S	S	L	M
CO-04	S	S	M	S	M	S	L	M	M	L	M	S	S
CO-05	L	S	L	L	S	M	L	L	L	M	L	S	L

S-Strong, M-Medium, L-Low, N-Not relevant

UNIT I: INTRODUCTION **9**

Challenges for wireless sensor networks, Comparison of sensor network with ad hoc network, Single node architecture – Hardware components, energy consumption of sensor nodes,

Network architecture – Sensor network scenarios, types of sources and sinks, single hop versus multi-hop networks, multiple sinks and sources – Introduction to LRWPAN – Design procedure for WSN development.

UNIT II: PHYSICAL INTRODUCTION LAYER 9

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

UNIT III: MAC PROTOCOLS 9

Issues in designing MAC protocols for adhoc wireless networks, design goals, classification of MAC protocols, MAC protocols for sensor network, location discovery, quality, other issues, S-MAC, IEEE 802.15.4.

UNIT IV: ROUTING PROTOCOLS 9

Issues in designing a routing protocol, classification of routing protocols, table-driven, on-demand, hybrid, flooding, hierarchical, and power aware routing protocols.

UNIT V: WSN DESIGN METHODOLOGY & APPLICATIONS 9

Network Simulators and Programming tools for WSN– Programming Challenges – Security Challenges – Implementation Issues – case study on networked control system. WSN Applications - Home Control - Building Automation - Industrial Automation - Medical Applications - Reconfigurable Sensor Networks -Highway Monitoring - Military Applications - Civil and Environmental Engineering Applications - Wildfire Instrumentation - Habitat Monitoring - Nanoscopic Sensor Applications.

TOTAL: 45 HOURS

REFERENCES:

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

		L	T	P	C
EI45B3	**INDUSTRIAL DATA COMMUNICATION**	**3**	**0**	**0**	**3**

OBJECTIVES

- To provide comprehensive knowledge of analog to digital conversion and data acquisition
- To explain pc based instrumentation systems.

Course Outcome		Cognitive Skill
CO-01	Ability to gain fundamental knowledge about various analog to digital conversion methods.	R, U
CO-02	Ability to gain knowledge about data acquisition.	U
CO-03	Ability to gain knowledge in the architecture and interfacing using microprocessors.	A
CO-04	Ability to learn the importance of PC based instrumentation using HART protocol.	An
CO-05	Ability to gain exposure on PC based industrial process measurements.	A

R-Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J	PO-K	PO-L
CO-01	S	L	M	L	L	L	S	S	S	M	M	M
CO-02	L	M	S	M	S	S	M	S	S	M	S	S
CO-03	M	M	L	S	S	L	S	M	S	S	S	L
CO-04	S	S	M	S	M	S	L	M	M	L	M	S
CO-05	L	S	L	L	S	M	L	L	L	M	L	S

S-Strong, M-Medium, L-Low,N-Not relevant

UNIT I: BASIC BLOCKS **9**

Overview of A/D converter, types and characteristics-Understanding Data acquisition, A/D and S/H terms-passive support and Active support components-Single and Multi-slope, Low cost A/D conversion techniques, types-Electromechanical A/D converter.

UNIT II: DATA ACQUISITION SYSTEMS **9**

Objective - Building blocks of Automation systems – Multi, Single channel Data Acquisition systems, PC based DAS, Data loggers- Sensors based computer data systems.

UNIT III: INTERFACING AND DATA TRANSMISSION **9**

Data transmission systems- 8086 Microprocessor based system design - Peripheral Interfaces – Time Division Multiplexing (TDM) – Digital Modulation – Pulse Modulation – Pulse Code Format – Interface systems and standards – Communications.

UNIT IV: PC BASED INSTRUMENTATION **9**

Introduction - Evolution of signal Standard - HART Communication protocol - Communication modes - HART networks - control system interface - HART commands - HART field controller implementation - HART and the OSI model - Field bus –Introduction - General field bus architecture - Basic requirements of field bus standard -field bus topology - Interoperability – interchangeability - Instrumentation buses-Mod bus - GPIB - Network buses – Ethernet - TCP/IP protocols.

UNIT V: CASE STUDIES **9**

PC based industrial process measurements like flow, temperature, pressure and level – PC based instruments development system.

TOTAL: 45 HOURS

REFERENCES:

1. Kevin M. Daugherty, "Analog – to – Digital conversion – A Practical Approach", McGraw Hill International Editions, 1995
2. N. Mathivanan, "Microprocessors, PC Hardware and Interfacing", Prentice – Hall of India Pvt. Ltd., 2003.
3. Krishna Kant "Computer- based Industrial Control", Prentice- Hall of India Pvt. Ltd., 1997
4. H S. Kalsi, "Electronic Instrumentation", Technical Education Series (TES)/TMH, New Delhi.
5. Buchanan., "Computer Busses", Arnold, London, 2000.

EI45B4	**SMART GRID**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES

- To Study about Smart Grid technologies, different smart meters and advanced metering infrastructure.
- To familiarize the power quality management issues in Smart Grid.
- To familiarize the high performance computing for Smart Grid applications.

Course Outcome		**Cognitive Skill**
CO-01	Learners will develop more understanding on the concepts of Smart Grid and its present developments.	R, U
CO-02	Learners will study about different Smart Grid technologies.	U
CO-03	Learners will acquire knowledge about different smart meters and advanced metering infrastructure.	An
CO-04	Learners will have knowledge on power quality management in Smart Grids	A

CO-05	Learners will develop more understanding on LAN, WAN and Cloud Computing for Smart Grids	A

R-Remember,U-Understand,A-Apply,An-Analyze,E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J	PO-K	PO-L
CO-01	S	L	M	L	L	L	S	S	S	M	M	M
CO-02	L	M	S	M	S	S	M	S	S	M	S	S
CO-03	M	M	S	S	S	L	S	M	L	S	S	L
CO-04	S	S	M	S	M	S	M	M	M	L	M	S
CO-05	L	S	L	L	S	M	L	L	L	M	L	L

S-Strong, M-Medium,L-Low,N-Not relevant

UNIT I: INTRODUCTION TO SMART GRID 9

Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, functions, opportunities, challenges and benefits, Difference between conventional & Smart Grid, National and International Initiatives in Smart Grid.

UNIT II: SMART GRID TECHNOLOGIES 9

Technology Drivers, Smart energy resources, Smart substations, Substation Automation, Feeder Automation ,Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and control, Distribution systems: DMS, Volt/Var control, Fault Detection, Isolation and service restoration, Outage management, High-Efficiency Distribution Transformers, Phase Shifting Transformers, Plug in Hybrid Electric Vehicles (PHEV).

UNIT III: SMART METERS AND ADVANCED METERING INFRASTRUCTURE 9

Introduction to Smart Meters, Advanced Metering infrastructure (AMI) drivers and benefits, AMI protocols, standards and initiatives, AMI needs in the smart grid, Phasor Measurement Unit (PMU), Intelligent Electronic Devices (IED) & their application for monitoring & protection.

UNIT IV: POWER QUALITY MANAGEMENT IN SMART GRID 9

Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit.

UNIT V: SMART GRID APPLICATIONS 9

Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), Broadband over Power line (BPL), IP based Protocols, Basics of Web Service and CLOUD Computing to make Smart Grids smarter, Cyber Security for Smart Grid.

TOTAL: 45 HOURS

REFERENCES:

1. Stuart Borlase "Smart Grid: Infrastructure, Technology and Solutions", CRC Press 2012.
2. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid: Technology and Applications", Wiley 2012.
3. Vehbi C. Güngör, Dilan Sahin, Taskin Kocak, Salih Ergüt, Concettina Buccella, Carlo Cecati, and Gerhard P. Hancke, "Smart Grid Technologies: Communication Technologies and Standards" IEEE Transactions on Industrial Informatics, Vol. 7, No. 4, November 2011.
4. Xi Fang, Satyajayant Misra, Guoliang Xue, and Dejun Yang "Smart Grid – The New and Improved Power Grid: A Survey", IEEE Transaction on Smart Grids, vol. 14, 2012.

OPEN ELECTIVE

SI.No.	SUBJECT CODE	SUBJECT NAME	L	T	P	C
1.	OE45D1	Research Methodology and IPR	2	0	0	2
2.	OE45D2	Business Analytics	3	0	0	3
3.	OE45D3	Industrial Safety	3	0	0	3
4.	OE45D4	Operations Research	3	0	0	3
5.	OE45D5	Composite Materials	3	0	0	3
6.	OE45D6	Waste to Energy	3	0	0	3

OE45D1	RESEARCH METHODOLOGY & IPR	L	T	P	C
		2	0	0	2

Course Outcome		Cognitive Skill
CO-01	Illustrate research problem formulation.	A, An
CO-02	Analyze research related information and research ethics.	An
CO-03	Correlate the results of any research article with other published results and write a review article in the field of engineering.	A, An, E
CO-04	Explain why intellectual property rights (IPR) will play such a significant role in the development of people and nations, and briefly discuss the necessity to spread awareness of IPR among students in general and engineers in particular.	A, An

CO-05	Discuss how IPR protection encourages innovators to conduct additional research and invest in R & D, which results in the development of new and improved products, which in turn leads to economic growth and societal benefits	A, An, E

R-Remember,U-Understand,A-Apply,An-Analyze,E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J	PO-K	PO-L
CO-01	S	S	S	M	M	S	M	M	M	M	M	S
CO-02	S	S	S	M	M	M	M	M	M	M	M	M
CO-03	S	S	S	M	M	M	S	M	M	M	S	S
CO-04	S	S	M	S	M	M	M	M	S	M	M	M
CO-05	S	M	M	M	M	S	M	S	S	M	S	M

S-Strong, M-Medium,L-Low,N-Not relevant

UNIT I: RESEARCH METHODOLOGY **6**

Meaning of research problem, Sources of research problem, Criteria and 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 SURVEY AND ETHICS **6**

Effective literature studies approaches - analysis Plagiarism - Research ethics.

UNIT III: TECHNICAL WRITING **6**

Effective technical writing - how to write a manuscript/ responses to reviewers comments - preparation of research article/ research report - Writing a Research Proposal - presentation and assessment by a review committee.

UNIT IV: INTELLECTUAL PROPERTY RIGHTS **6**

Nature of Intellectual Property: Patents, Designs, Trade Mark and Copyright - Process of Patenting and Development: technological research, innovation, patenting & development - Procedure for grants of patents - Patenting under PCT.

UNIT V: PATENT RIGTS AND NEW DEVELOPMENTS IN IPR **6**

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

TOTAL: 30 HOURS

TEXT BOOKS:

1. C.R.Kothari, "Research Methodology", 3rd Edition, New Age International, 2017.
2. Ranjit Kumar, "Research Methodology – A Step by Step for Beginner's", 2nd Edition, Pearson, Education, 2016.
3. Ann M. Korner, Guide to Publishing a Scientific paper, Bioscript Press 2004.
4. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008.
5. Kompal Bansal & Parshit Bansal, "Fundamentals of IPR for Beginner's", 1st Edition, BS Publications, 2016.

REFERENCES:

1. Kothari, C. R. Research Methodology - Methods and Techniques, New Age International publishers, New Delhi, 2004.
2. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students', Juta & Company, 1996.
3. Robert P. Merges, Peter S. Menell and Mark A. Lemley, "Intellectual Property in New Technological Age", Aspen Publishers, 2016.
4. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd, 2007.
5. Mayall, "Industrial Design", McGraw Hill, 1992.
6. Niebel, "Product Design", McGraw Hill, 1974. 7. Asimov, "Introduction to Design", Prentice Hall, 1962.

WEB RESOURCES:

1. https://nptel.ac.in/courses/106/105/106105077/

OE45D2	**BUSINESS ANALYTICS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES

- To provide sound knowledge in the basic concepts of linear control theory and design of control system.

Course Outcome		**Cognitive Skill**
CO-01	Analyze business data using statistical tools.	An
CO-02	Apply trend analysis and regression to make informed decisions.	A
CO-03	Design organizational structures for effective business analytics.	A, An, E

CO-04	Utilize forecasting techniques for prediction and decision-making.	An, S
CO-05	Employ decision analysis methods and stay updated on recent trends in business intelligence and data storytelling.	A, An

R-Remember,U-Understand,A-Apply,An-Analyze,E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J	PO-K	PO-L
CO-01	S	M	M	M	M	S	M	M	M	M	M	S
CO-02	S	S	S	M	M	M	M	M	M	M	M	M
CO-03	S	M	S	M	M	M	S	M	M	M	S	S
CO-04	S	S	M	S	M	M	M	M	S	M	M	M
CO-05	S	M	M	M	M	S	M	S	S	M	S	M

S-Strong, M-Medium,L-Low,N-Not relevant

UNIT I **9**

Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics.

Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.

UNIT II **9**

Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression.

Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.

UNIT III **9**

Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes. Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.

UNIT IV **9**

Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models.

Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model.

UNIT V **9**

Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making, Recent Trends in : Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.

TOTAL: 45 HOURS

REFERENCE BOOKS:

1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.
2. Business Analytics by James Evans, persons Education.

OE45D3	**INDUSTRIAL SAFETY**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Course Outcome		**Cognitive Skill**
CO-01	Identify and mitigate industrial safety hazards effectively.	U, A
CO-02	Apply maintenance engineering principles to optimize equipment performance.	A
CO-03	Implement strategies for wear reduction and corrosion prevention.	An
CO-04	Utilize fault tracing techniques to diagnose equipment problems efficiently.	A, An
CO-05	Develop and execute periodic and preventive maintenance programs for machinery and equipment	A, An, E

R-Remember,U-Understand,A-Apply,An-Analyze,E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J	PO-K	PO-L
CO-01	S	S	S	M	M	S	M	M	M	M	M	S
CO-02	S	S	S	M	M	M	M	M	M	M	M	M
CO-03	S	S	S	M	M	M	S	M	M	M	S	S
CO-04	S	S	M	S	M	M	M	M	S	M	M	M
CO-05	S	M	M	M	M	S	M	S	S	M	S	M

S-Strong, M-Medium,L-Low,N-Not relevant

UNIT I **9**

Industrial safety: 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 **9**

Fundamentals of maintenance engineering: 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 **9**

Wear and Corrosion and their prevention: 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 **9**

Fault tracing: Fault tracing-concept and importance, decision treeconcept, 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 **9**

Periodic and preventive maintenance: 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 HOURS

REFERENCE BOOKS:

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

OE45D4	**OPERATIONS RESEARCH**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Course Outcome		**Cognitive Skill**
CO-01	Formulate and solve optimization problems using simplex method, sensitivity analysis, and parametric programming.	A
CO-02	Apply linear programming to model real-world scenarios, understand duality theory, and analyze sensitivity.	A, U
CO-03	Solve nonlinear programming problems with Kuhn-Tucker conditions.	A, An
CO-04	Develop scheduling and sequencing models for resource utilization and inventory control.	A, E
CO-05	Apply competitive modeling, dynamic programming, and game theory to optimize decision-making in various scenarios.	A

R-Remember,U-Understand,A-Apply,An-Analyze,E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J	PO-K	PO-L
CO-01	S	M	M	M	M	S	M	S	M	M	S	S
CO-02	S	S	S	M	M	M	M	S	M	M	S	M
CO-03	S	M	S	M	M	M	S	M	M	M	S	S
CO-04	S	S	M	S	M	M	M	M	S	M	S	M
CO-05	S	M	M	M	M	S	M	S	S	M	S	M

S-Strong, M-Medium,L-Low,N-Not relevant

UNIT I **9**

Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models.

UNIT II **9**

Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming.

UNIT III **9**

Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT.

UNIT IV **9**

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

UNIT V **9**

Competitive Models, Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation.

TOTAL: 45 HOURS

REFERENCE BOOKS:

1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009
5. Pannerselvam, Operations Research: Prentice Hall of India 2010
6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010

OE45D5	COMPOSITE MATERIALS	L	T	P	C
		3	0	0	3

Course Outcome		Cognitive Skill
CO-01	Understand the classification, characteristics, and advantages of composite materials, along with their applications in various industries.	U
CO-02	Demonstrate knowledge of different reinforcements used in composites and their preparation methods, properties, and applications.	A, An
CO-03	Gain proficiency in manufacturing metal matrix composites, ceramic matrix composites, and polymer matrix composites, including understanding the processes involved and their resulting properties.	U, An, E
CO-04	Analyze the mechanical behavior and strength of composite materials, including failure criteria and design considerations for laminated structures.	An
CO-05	Apply learned concepts to solve real-world problems related to the design, manufacturing, and application of composite materials in engineering projects.	A

R-Remember,U-Understand,A-Apply,An-Analyze,E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J	PO-K	PO-L
CO-01	M	S	M	M	M	S	M	M	M	M	M	S
CO-02	M	S	S	M	M	M	M	M	M	M	M	M
CO-03	M	S	S	M	M	M	S	M	M	M	S	S
CO-04	M	S	M	S	M	M	M	M	S	M	M	M
CO-05	M	S	M	M	M	S	M	S	S	M	S	M

S-Strong, M-Medium,L-Low,N-Not relevant

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 HOURS

TEXT BOOKS:

1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.

REFERENCES:

1. Hand Book of Composite Materials-ed-Lubin.
2. Composite Materials – K.K.Chawla.
3. Composite Materials Science and Applications – Deborah D.L. Chung.
4. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi.

OE45D6	**WASTE TO ENERGY**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Course Outcome		**Cognitive Skill**
CO-01	Identify and classify waste types for energy generation.	U, An
CO-02	Apply biomass pyrolysis and gasification techniques.	A, S
CO-03	Understand biomass combustion principles and technologies.	U, A

CO-04	Analyze biogas properties, plant technology, and applications.	An
CO-05	Evaluate biomass conversion processes and related energy programs.	A, An, E

R-Remember,U-Understand,A-Apply,An-Analyze,E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J	PO-K	PO-L
CO-01	M	M	S	S	M	S	M	S	M	M	S	S
CO-02	M	M	S	S	M	M	M	S	M	M	S	S
CO-03	M	M	S	S	M	M	S	S	M	M	S	S
CO-04	M	M	S	S	M	M	M	S	S	M	S	S
CO-05	M	M	S	S	M	S	M	S	S	M	S	S

S-Strong, M-Medium, L-Low, N-Not relevant

UNIT I: INTRODUCTION TO ENERGY FROM WASTE **9**

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

UNIT II: BIOMASS PYROLYSIS **9**

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

UNIT III: 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.

UNIT IV: 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.

UNIT V: BIOGAS **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 HOURS

REFERENCES:

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