KONGU ENGINEERING COLLEGE
PERUNDURAI ERODE – 638 060
(Autonomous)

VISION

To be a centre of excellence for development and dissemination of knowledge in Applied Sciences, Technology, Engineering and Management for the Nation and beyond.

MISSION

We are committed to value based Education, Research and Consultancy in Engineering and Management and to bring out technically competent, ethically strong and quality professionals to keep our Nation ahead in the competitive knowledge intensive world.

QUALITY POLICY

We are committed to

- Provide value based quality education for the development of students as competent and responsible citizens.
- Contribute to the nation and beyond through research and development
- Continuously improve our services

ME- CONTROL AND INSTRUMENTATION ENGINEERING

VISION

To become a technically competent centre in the domain of Control and Instrumentation Engineering to take care of the national and international needs.

MISSION

Department of Control and Instrumentation Engineering is committed to:

MS1: To develop innovative, competent, efficient, disciplined and quality Control and Instrumentation Engineers.

MS2: To produce engineers who can participate in technical advancement and social upliftment of the country.

MS3: To excel in academic and research activities by facilitating the students to explore the state-of – the –art techniques to meet the industrial needs

2018 REGULATIONS

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

Graduates of Control and Instrumentation Engineering will

PEO1: Excel in professional career with the competency to address the technical needs of society and industrial problems ethically.

PEO2: Foster research and demonstrate life-long independent and reflective ingenuity in their career.

PEO3: Exhibit project management skills and ability to work in collaborative, multidisciplinary tasks in their profession.

MAPPING OF MISSION STATEMENTS (MS) WITH PEOs

MS\PEO	PEO1	PEO2	PEO3
MS1	3	2	1
MS2	2	3	2
MS3	1	3	3

1 – Slight, 2 – Moderate, 3 – Substantial

PROGRAM OUTCOMES (POs)

Engineering Post Graduates will be able to:

PO1: Carry out research /investigation independently and develop work to solve practical problems.

PO2: Write and present a substantial technical report/document.

PO3: Demonstrate a degree of mastery over the area of Control and Instrumentation Engineering.

PO4: Perform in multidisciplinary environment by maintaining ethics and enhance continuous learning.

MAPPING OF PEOs WITH POs

PEO\PO	PO1	PO2	PO3	PO4
PEO1	3	1	3	2
PEO2	2	2	1	3
PEO3	2	3	2	3

1 – Slight, 2 – Moderate, 3 – Substantial

CURRICULUM BREAKDOWN STRUCTURE UNDER REGULATION 2018

Curriculum Breakdown Structure(CBS)	Curriculum Content (% of total number of credits of the program)	Total number of contact hours	Total number of credits
Basic Science (BS)	5.55	60	4
Program Core(PC)	41.66	480	30
Program Electives(PE)	25.00	270	18
Project(s)/Internships(PR)/Others	27.77	1098	20
		Total	**72**

KEC R2018: SCHEDULING OF COURSES – ME-CONTROL AND INSTRUMENTATION ENGINEERING

Semes ter	Theory/ Theory cum Practical / Practical							Internship & Projects	Special Courses	Credits
	1	2	3	4	5	6	7	8	9	
I	18AMT15 Applied Mathematics for Control Engineers (BS-3-1-0-4)	18CIC11 Smart Sensors and Its Interfaces (PC-3-0-2-4)	18CIT11 Process Dynamics and Control (PC-3-1-0-4)	18CIT12 Neural Networks and Deep Learning (PC-3-0-0-3)	18CIT13 Linear System Theory (PC-3-1-0-4)	18GET01 Introduction to Research (PC-3-0-0-3)	18CIL Process Dynamics and Control Laboratory (PC-0-0-2-1)	---	--	23
II	18CIT21 Multirate and Sparse Signal Processing (PC-3-1-0-4)	18CIT22 Industrial Automation and Networking (PC-3-0-0-3)	18CIC21 Non-Linear System Analysis and Control (PC-3-0-2-4)	Professional Elective-1 (PE-3-0-0-3)	Professional Elective-2 (PE-3-0-0-3)	Professional Elective-3 (PE-3-0-0-3)	--	18CIP21 Mini Project (PR-0-0-4-2)	--	22
III	Professional Elective-4 (PE-3-0-0-3)	Professional Elective-5 (PE-3-0-0-3)	Professional Elective-6 (PE-3-0-0-3)	--	--	--	--	18CIP31 Project Work Phase I (PR-0-0-12-6)	--	15
IV	--	--	--	--	--	--	--	18CIP41 Project Work Phase II (PR-0-0-24-12)	--	12

Total Credits: 72

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M.E. DEGREE IN CONTROL AND INSTRUMENTATION ENGINEERING

CURRICULUM

(For the candidates admitted from academic year 2018-19 onwards)

SEMESTER – I

Course Code	Course Title	Hours / Week			Credit	Maximum Marks			CBS
		L	T	P		CA	ESE	Total	
	Theory/Theory with Practical								
18AMT15	Applied Mathematics for Control Engineers	3	1	0	4	50	50	100	PC
18CIC11	Smart Sensors and Its Interfaces	3	0	2	4	50	50	100	PC
18CIT11	Process Dynamics and Control	3	1	0	4	50	50	100	PC
18CIT12	Neural Networks and Deep Learning	3	0	0	3	50	50	100	PC
18CIT13	Linear System Theory	3	1	0	4	50	50	100	PC
18GET01	Introduction to Research	3	0	0	3	50	50	100	PC
	Practical								
18CIL11	Process Dynamics and Control Laboratory	0	0	2	1	100	0	100	PC
	Total				**23**				

CA – Continuous Assessment, ESE – End Semester Examination, CBS – Curriculum Breakdown Structure

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M.E. DEGREE IN CONTROL AND INSTRUMENTATION ENGINEERING

CURRICULUM

(For the candidates admitted from academic year 2018-19 onwards)

SEMESTER – II

Course Code	Course Title	Hours / Week			Credit	Maximum Marks			CBS
		L	T	P		CA	ESE	Total	
	Theory/Theory with Practical								
18CIT21	Multirate and Sparse Signal Processing	3	1	0	4	50	50	100	PC
18CIT22	Industrial Automation and Networking	3	0	0	3	50	50	100	PC
18CIC21	Non-Linear System Analysis and Control	3	0	2	4	50	50	100	PC
	Elective - I	3	0	0	3	50	50	100	PE
	Elective - II	3	0	0	3	50	50	100	PE
	Elective - III	3	0	0	3	50	50	100	PE
	Practical								
18CIP21	Mini Project	0	0	4	2	100	0	100	PR
	Total				**22**				

CA – Continuous Assessment, ESE – End Semester Examination, CBS – Curriculum Breakdown Structure

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M.E. DEGREE IN CONTROL AND INSTRUMENTATION ENGINEERING

CURRICULUM
(For the candidates admitted from academic year 2018-19 onwards)

SEMESTER – III

Course Code	Course Title	Hours / Week			Credit	Maximum Marks			CBS
		L	T	P		CA	ESE	Total	
	Theory/Theory with Practical								
	Elective - IV	3	0	0	3	50	50	100	PE
	Elective - V	3	0	0	3	50	50	100	PE
	Elective - VI	3	0	0	3	50	50	100	PE
	Practical								
18CIP31	Project Work Phase I	0	0	12	6	50	50	100	PR
	Total				**15**				

CA – Continuous Assessment, ESE – End Semester Examination, CBS – Curriculum Breakdown Structure

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M.E. DEGREE IN CONTROL AND INSTRUMENTATION ENGINEERING

CURRICULUM
(For the candidates admitted from academic year 2018-19 onwards)

SEMESTER – IV

Course Code	Course Title	Hours / Week			Credit	Maximum Marks			CBS
		L	T	P		CA	ESE	Total	
	Practical								
18CIP41	Project Work Phase II	0	0	24	12	50	50	100	PR
	Total				**12**				

CA – Continuous Assessment, ESE – End Semester Examination, CBS – Curriculum Breakdown Structure

Total Credits: 72

LIST OF PROFESSIONAL ELECTIVES						
Course Code	**Course Title**	**Hours/Week**			**Credit**	**CBS**
		L	**T**	**P**		
SEMESTER II						
18MTC21	Robotics Engineering	3	0	2	4	PE
18COT21	Wireless Sensor Networks	3	1	0	4	PE
18MSC21	Machine Learning Techniques	3	0	2	4	PE
18CIE01	Optimal and Adaptive Control	3	0	0	3	PE
18CIE02	Advanced Instrumentation System Design	3	0	0	3	PE
18CIE03	Instrumentation in Automobiles and Building Automation	3	0	0	3	PE
18CIE04	Bioprocess Instrumentation and Control	3	0	0	3	PE
18CIE05	Digital Instrumentation	3	0	0	3	PE
18CIE06	Piping and Instrumentation Design in Process Industries	3	0	0	3	PE
18CIE07	Applied Industrial Instrumentation	3	0	0	3	PE
SEMESTER III						
18MTE13	MEMS Design	3	0	0	3	PE
18CIE08	Security for SCADA System	3	0	0	3	PE
18CIE09	Robust Control	3	0	0	3	PE
18CIE10	Digital System and Logic Synthesis	3	0	0	3	PE
18CIE11	Computer Vision and Image Processing	3	0	0	3	PE
18CIE12	Industrial Drives and Control	3	0	0	3	PE
18CIE13	Embedded FPGA based Control Design	3	0	0	3	PE
18CIE14	Wireless Embedded Systems	3	0	0	3	PE
18CIE15	Virtual Instrumentation for Industrial Applications	3	0	0	3	PE

18AMT15 APPLIED MATHEMATICS FOR CONTROL ENGINEERS

L	T	P	Credit
3	1	0	4

Preamble	This course is to demonstrate various analytical skills in applied mathematics and extensive experience with the tactics of problem solving and logical thinking applicable in control and instrumentation engineering.
Prerequisites	Calculus and Probability.

UNIT – I **9**

Vector Spaces: Definition - Subspaces - Linear dependence and independence - Basis and dimension - Row space, Column space and Null Space - Rank and nullity.

UNIT – II **9**

Inner Product Spaces: Inner products - Angle and Orthogonality in inner product spaces - Orthonormal Bases - Gram-Schmidt Process - QR-Decomposition - Orthogonal Projection - Least square technique.

UNIT – III **9**

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

UNIT – IV **9**

Random Variables: Probability function – Moments – Moment generating functions and their properties – Probability distributions: Binomial, Poisson, Geometric, Uniform, Exponential, Gamma and Normal distributions.

UNIT – V **9**

Stochastic Process Classification – Stationary Random process – Markov process – Gaussian process – Markov chain – Auto Correlation – Cross correlation– Response of linear system to random input.

Lecture: 45, Tutorial: 15, Total: 60

REFERENCES:

1. Howard Anton, Chris Rorres, "Elementary Linear Algebra", John Wiley & Sons, 2010.
2. Gupta A.S., "Calculus of Variations with Applications", 12th Edition, Prentice Hall of India Pvt. Ltd., New Delhi, 2015.
3. Johnson R.A., Miller I., and Freund J., "Miller and Freund's Probability and Statistics for Engineers", 9th Edition, Pearson Education, Asia, 2016.

Course Outcomes: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	handle problems in linear algebra	Applying (K3)
CO2:	understand inner product space concepts and use it in various linear system related applications	Applying (K3)
CO3:	apply the concepts of maximizing and minimizing the functional that occur in control engineering	Evaluating (K5)
CO4:	identify various probability distributions and use it to solve engineering problems	Applying (K3)
CO5:	identify responses of linear systems to any given input signal	Applying (K3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4
CO1	1			
CO2	2			
CO3	1			
CO4	2			
CO5	2			

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18CIC11 SMART SENSORS AND ITS INTERFACES

L	T	P	Credit
3	0	2	4

Preamble	The course uses a multidisciplinary approach to review recent developments in the field of smart sensor systems, providing complete coverage of all important system and design aspects, their building blocks and methods of signal processing.
Prerequisites	Transducer Engineering, Measurements and Instrumentation

UNIT – I **9**

Smart Sensor Architecture and Fabrication: Definition - Importance and Adoption of Smart Sensor - Architecture of Smart Sensors: Important components - their features - Amplification - Filters - Converters - Compensation - Information coding / processing - Electrode fabrication: Photolithography - Electroplating Sensing film deposition: Physical and Chemical Vapor - Anodization - Sol-gel.

UNIT – II **9**

Sensor Interfacing: Data communication - Standards for Smart Sensor Interface - Smart transmitter with HART communicator - Interfacing of Temperature, Pressure, Humidity and Flow sensors.

UNIT – III **9**

Sensors for Spatial Variables, Optical Variables and Thermal Variables: Spatial variable measurement: Laser Interferometer Displacement Sensor - Synchro / Resolver displacement transducer. Optical variables measurement: Sensor Arrays, Integrated Micro Array - Vision and Image Sensors. Thermal composition measurement: Thermogravimetry

UNIT – IV **9**

Environmental Measurement Sensors and Tactile Sensors: Environmental measurement: Meteorological measurement - Satellite imaging and sensing. Aerospace Sensor: Laser Gyroscope and accelerometers. Tactile sensing: Sensing Classification - Simplified Theory for Tactile Sensing - Requirements for Tactile Sensors - Technologies for Tactile Sensing.

UNIT – V **9**

Recent Trends in Sensor Technologies: Film sensors: Thick film and Thin film - Sensors - Clean Room Technology - Bio sensors - Sensor network - Multisensor data fusion - Soft sensor.

List of Exercises / Experiments :

1. Design of signal conditioning circuit for temperature measuring device.
2. Design of signal conditioning circuit for smart sensor.
3. Synchro Transmitter-Receiver Characteristics.
4. Position control using AC servo mechanism.
5. Realisation of Data Acquisition System.

Lecture:45, Practical:30, Total: 75

REFERENCES:

1. Bela G. Liptak, “Instruments Engineers’ Handbook Process Measurement and Analysis”, Elsevier, 2005.
2. Patranabis D., “Sensors and Transducers”, 2nd Edition, Prentice Hall of India, 2010.
3. John G. Webster, “Measurement, Instrumentation and Sensors Handbook”, CRC Press, 1998.

COURSE OUTCOMES: On completion of the course, the students will be able to		BT Mapped (Highest Level)
CO1:	interpret the concepts of sensor fabrication	Understanding (K2)
CO2:	explain the standards to interface the smart sensors with protocol	Understanding(K2)
CO3:	carryout the measurements of physical, thermal and optical variables using suitable sensors	Applying(K3)
CO4:	employ sensors for environmental, aerospace and tactile sensing	Applying(K3)
CO5:	execute the various trends in smart sensors technologies for different cases	Applying(K3)
CO6:	integrate signal conditioning circuit for temperature measurements	Analyzing(K4), Precision(S3)
CO7:	experiment position control AC servo mechanism	Analyzing(K4), Precision(S3)
CO8:	make realization of DAQ	Applying(K3), Precision(S3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4
CO1	2	2		
CO2	2	2		
CO3	2	2	1	1
CO4	3	3	1	1
CO5	3	3	1	1
CO6	3	3	3	3
CO7	3	3	3	3
CO8	3	3	3	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom’s Taxonomy

18CIT11 PROCESS DYNAMICS AND CONTROL

L	T	P	Credit
3	1	0	4

Preamble	To provide solution towards better control action for various process applications
Prerequisites	Process Control, Control Systems

UNIT – I **9**

Process Modeling and Dynamics: Mathematical modeling: Non-interacting system and Interacting system - single conical tank – single spherical tank – mixing process – Thermal systems: CSTR and distillation column. Servo and Regulatory control.

UNIT – II **9**

Control Actions: Characteristic of ON-OFF, P, P+I, P+D and P+I+D control modes – Electronic controllers – Pneumatic Controllers. **Controller Tuning:** Process Reaction Curve method, Z-N method, Relay-auto tuning method.

UNIT – III **9**

Multivariable Systems: Transfer Matrix Representation - Poles and Zeros of MIMO System - Multivariable frequency response analysis - Directions in multivariable systems - Singular value decomposition. **Multi-Loop Regulatory Control:** Introduction - Process Interaction - Pairing of controlled and manipulated variables.

UNIT – IV **9**

RGA: Properties and Applications of RGA - Decoupling Control - Multi-loop PID Controller - Biggest Log Modulus Tuning Method. **Multivariable Regulatory Control:** Multivariable IMC - Multivariable DMC - Multivariable MPC - Multiple Model based Predictive Controller.

UNIT – V **9**

Advanced Control Schemes: Feedback and Feed forward control - Ratio control - Cascade control - Split-range control - Inferential control - Selective control. **Case Studies:** Control Schemes for Distillation Column - CSTR and pH.

Lecture:45, Tutorial:15, Total: 60

REFERENCES:

1. Wayne Bequette B., “Process Control: Modeling, Design, and Simulation”, Prentice Hall of India, 2004.
2. Stephanopoulos G., “Chemical Process Control-An Introduction to Theory and Practice”, Prentice Hall of India, New Delhi, 2008.
3. Dale E. Seborg, Duncan A. Mellichamp, Thomas F. Edgar, and Francis J. Doyle, “Process Dynamics and Control”, John Wiley and Sons, 2010.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	develop mathematical modeling for various processes	Applying(K3)
CO2:	identify various control actions and controller tuning methods for various applications	Analyzing(K4)
CO3:	explain the concepts of multivariable systems and multi-loop regulatory control techniques	Understanding(K2)
CO4:	calculate RGA to analyse process interactions and to describe multi-variable regulatory control techniques	Applying(K3)
CO5:	apply various advanced control schemes for various applications	Applying(K3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4
CO1	3	3	1	1
CO2	3	3	2	2
CO3	2	2		
CO4	3	3	1	1
CO5	3	3	1	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18CIT12 NEURAL NETWORKS AND DEEP LEARNING

L	T	P	Credit
3	0	0	3

Preamble	To help the students to master the core concepts of neural networks, including modern techniques for deep learning
Prerequisites	Mathematics

UNIT – I **9**

Mathematical Review: Statistical Concepts - Bayes' Theorem - Random Variables - Linear Algebra - Matrices - Norms - Eigenvalues and Eigenvectors, Eigenvalue Decomposition - Gradient Descent (GD) - Momentum Based GD - Nesterov Accelerated GD - Stochastic GD.

UNIT – II **9**

Artificial Neural Networks: Characteristics of biological and Artificial neural networks. Supervised learning Network: Hebb - Perceptron Network, Back Propagation Network.

UNIT – III **9**

Neural Networks: Unsupervised Learning networks: Kohonen Self-Organizing Feature Maps, Radial Basis Function, RBF Neural Networks.

UNIT – IV **9**

Introduction to Deep Learning: Review of Machine Learning - Fundamentals of Deep Learning Networks - History of Deep learning - Applications - Deep Learning Models: Single Layer Perceptron Model (SLP) - Multilayer Perceptron Model (MLP) - Recurrent Neural Networks (RNNs)

UNIT – V **9**

Deep Learning and Its Applications: Deep Learning Models: Restricted Boltzmann Machines (RBMs) - Deep Belief Networks (DBNs) - Convolutional Neural Networks (CNNs) - LeNet, GooleNet - A simple deep learning model for stock price prediction - Efficient Medical Image Processing

Total: 45

REFERENCES:

1. Dr. Sivanandam S.N., and Dr. Deepa S.N., "Principles of Soft Computing", 2nd Edition, Wiley India, 2012.
2. Ian Goodfellow, Yoshua Bengio and Aaron Courvillie, "Deep Learning", The MIT Press Cambridge, Massachusetts, London England, 2016.
3. Josh Patterson, "Deep Learning - A Practitioners Approach", O'Reilly, 2017.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	apply the basic mathematical concepts involved in computing techniques	Applying(K3)
CO2:	summarize the fundamentals of artificial neural networks	Understanding(K2)
CO3:	implement the various neural algorithms for classification and function approximation	Applying(K3)
CO4:	explain the architecture model of deep learning	Understanding(K2)
CO5:	execute the new application requirements in the field of computer vision	Applying(K3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4
CO1	3	3	1	1
CO2	2	2		
CO3	3	3	1	1
CO4	2	2		
CO5	3	3	1	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18CIT13 LINEAR SYSTEM THEORY

L	T	P	Credit
3	1	0	4

Preamble	To analyze the behavior of linear system in state model and to design state feedback controllers and observers both in continuous and discrete domain
Prerequisites	Control systems

UNIT – I **9**

State Modeling in Continuous Domain: Review of state variable representation and state variable models in continuous systems. Conversion from transfer function to various state space model - conversion of state space model to transfer function. Applications: DC motor, Inverted pendulum.

UNIT – II **9**

State Modeling in Discrete Domain: Review of Z-Transform - Review of Sampling Theory - Sample and Hold circuits - Pulse Transfer Function - Sampled Data Control System: transfer function model, state space model. Modified Z Transform. Applications: DC motor, Inverted pendulum.

UNIT – III **9**

State Solutions in Continuous and Discrete Domain: Eigen values and eigen vectors - State transition matrix and its properties. Solutions of state equations - continuous and discrete - free and forced responses - Stability of Sampled Data Control System - Jury's Stability Test - Applications: DC motor, Inverted pendulum.

UNIT – IV **9**

State Feedback Controllers in Continuous and Discrete Domain: Controllability and observability - relation between transfer function and state model - effect of sampling time on controllability and observability - state feedback controllers. Steady state error in state model - PI feedback controller - Dead beat Control - Applications: DC motor, Inverted pendulum.

UNIT – V **9**

State Estimators in Continuous and Discrete Domain: Deterministic observer - full and reduced order observer - dead beat observer - stochastic observer: review of random process - least mean square estimation - Kalman filter - Kalman - Bucy filter - Applications: DC motor, Inverted pendulum.

Lecture:45, Tutorial:15, Total: 60

REFERENCES:

1. Gopal M., "Digital Control and State Variable Methods", 4th Edition, Tata McGraw-Hill, New Delhi, 2014.
2. Richard C. Dorf and Robert H. Bishop, "Modern Control Systems", 11th Edition, Pearson Publications, 2013.
3. Mohinder S. Grewal and Angus P. Andrews, "Kalman Filtering: Theory and Practice with Matlab", 4th Edition, Wiley Publications, 2015.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	formulate state models of continuous and discrete systems	Applying(K3)
CO2:	analyze the state responses of continuous and discrete systems	Analyzing(K4)
CO3:	analyze the stability of the systems in continuous and discrete systems	Analyzing(K4)
CO4:	evaluate the performance of state feedback controllers	Evaluating(K5)
CO5:	implement state estimators	Applying(K3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4
CO1	3	3	1	1
CO2	3	3	2	2
CO3	3	3	2	2
CO4	3	3	3	3
CO5	3	3	1	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18GET01 INTRODUCTION TO RESEARCH

(Common to Engineering and Technology Branches)

L	T	P	Credit
3	**0**	**0**	**3**

Preamble	To familiarize the fundamental concepts/techniques adopted in research, problem formulation and patenting and to disseminate the process involved in collection, consolidation of published literature and rewriting them in a presentable form using latest tools.
Prerequisites	Nil

UNIT – I **9**

Concept of Research: Meaning and Significance of Research: Skills, Habits and Attitudes for Research - Time Management - Status of Research in India. Why, How and What a Research is? - Types and Process of Research - Outcome of Research - Sources of Research Problem - Characteristics of a Good Research Problem - Errors in Selecting a Research Problem - Importance of Keywords - Literature Collection – Analysis - Citation Study - Gap Analysis - Problem Formulation Techniques.

UNIT – II **9**

Research Methods and Journals: Interdisciplinary Research - Need for Experimental Investigations - Data Collection Methods - Appropriate Choice of Algorithms / Methodologies / Methods - Measurement and Result Analysis - Investigation of Solutions for Research Problem - Interpretation - Research Limitations. Journals in Science/Engineering - Indexing and Impact factor of Journals - Citations - h Index - i10 Index - Journal Policies - How to Read a Published Paper - Ethical issues Related to Publishing - Plagiarism and Self-Plagiarism.

UNIT – III **9**

Paper Writing and Research Tools: Types of Research Papers - Original Article/Review Paper/Short Communication/Case Study - When and Where to Publish? - Journal Selection Methods. Layout of a Research Paper - Guidelines for Submitting the Research Paper - Review Process - Addressing Reviewer Comments. Use of tools / Techniques for Research - Hands on Training related to Reference Management Software - EndNote, Software for Paper Formatting like LaTeX/MS Office. Introduction to Origin, SPSS, ANOVA etc., Software for detection of Plagiarism.

UNIT – IV **9**

Effective Technical Thesis Writing/Presentation: How to Write a Report - Language and Style - Format of Project Report - Use of Quotations - Method of Transcription Special Elements: Title Page - Abstract - Table of Contents - Headings and Sub-Headings - Footnotes - Tables and Figures - Appendix - Bibliography etc. - Different Reference Formats. Presentation using PPTs.

UNIT – V **9**

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

Total: 45

REFERENCES:

1. DePoy, Elizabeth, and Laura N. Gitlin, “Introduction to Research-E-Book: Understanding and Applying Multiple Strategies”, Elsevier Health Sciences, 2015.
2. Walliman, Nicholas, “Research Methods: The basics”, Routledge, 2017.
3. Bettig Ronald V., “Copyrighting culture: The political economy of intellectual property”, Routledge, 2018.

COURSE OUTCOMES: On completion of the course, the students will be able to		BT Mapped (Highest Level)
CO1:	list various stages in research/patenting and categorize the quality of journals	Analyzing (K4)
CO2:	formulate a research problem from published literature/journal papers	Evaluating (K5)
CO3:	write, present a journal paper/ project report using latest tools in proper format	Creating (K6)
CO4:	select suitable journal and submit a research paper	Applying (K3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3
CO1	3	2	1
CO2	3	2	3
CO3	3	3	1
CO4	3	2	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT – Bloom's Taxonomy

18CIL11 PROCESS DYNAMICS AND CONTROL LABORATORY

L	T	P	Credit
0	0	2	1

Preamble	To provide practical solution towards better control action for various process applications
Prerequisites	Process Control, Control Systems

List of Exercises / Experiments :

1. For the First Order Linear System, determine the mathematical modeling to obtain the response of the systems with different test inputs and check the servo and regulatory operations.
2. For the First Order Non Linear System, determine the mathematical modeling to obtain the response of the systems with different test inputs and check the servo and regulatory operations.
3. For the Second Order Linear System, determine the mathematical modeling to obtain the response of the systems with different test inputs and check the servo and regulatory operations.
4. For the Second Order Non Linear System, determine the mathematical modeling to obtain the response of the systems with different test inputs and check the servo and regulatory operations.
5. Develop control schemes for the heat exchanger and verify their performances by simulation.
6. Develop control schemes for the pH neutralization plant and verify their performances by simulation.
7. For the multivariable process, determine the controller parameters using relay auto tuning method.

Total: 30

REFERENCES/MANUALS/SOFTWARES:

1. Wayne Bequette B., "Process Control: Modeling, Design, and Simulation", Prentice Hall of India, 2004.
2. Stephanopoulos G., "Chemical Process Control-An Introduction to Theory and Practice", Prentice Hall of India, New Delhi, 2008.
3. Process Control Lab Manual, Department of EIE, Kongu Engineering College, 2014.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	carryout modeling and identify the suitable controller design for various processes	Applying(K3), Precision(S3)
CO2:	analyze servo and regulatory performances of the selected process	Analyzing(K4), Precision(S3)
CO3:	develop control schemes for various processes	Applying(K3), Precision(S3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4
CO1	3	3	3	3
CO2	3	3	3	3
CO3	3	3	3	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18CIT21 MULTIRATE AND SPARSE SIGNAL PROCESSING

L	T	P	Credit
3	1	0	4

Preamble	The course aims to state various techniques in discrete random signal process, design Wiener and Adaptive filtering technique, apply Multirate signal processing techniques, analyze Uniform and two channel filter banks, explain the concept of Sparse signal processing and apply the knowledge of advanced digital signal processing techniques.
Prerequisites	Digital Signal Processing

UNIT – I **9**

Discrete Time Random Processes: Random processes: Ensemble averages - Covariance and Correlation matrices –Ergodicity-White noise-Parseval's theorem –Wiener Khintchine relation -Filtering random processes –Spectral Factorization Theorem. Special type of Random Process: Autoregressive Moving Average Processes, Autoregressive Processes, Moving Average Processes.

UNIT – II **9**

Wiener and Adaptive Filter: Wiener Filter: The FIR Wiener filters –Filtering –Noise cancellation. IIR Wiener filter –Non causal IIR Wiener filter –Causal IIR Wiener filter. Adaptive Filter: Concepts of adaptive filter –FIR adaptive filters –LMS algorithm –Adaptive recursive filter.

UNIT – III **9**

Multirate Signal Processing and Digital Filter Banks: Introduction-Decimation by a factor D –Interpolation by a factor I –Sampling rate conversion by Rational Factor I/D –Implementation of sampling rate conversion –Multistage implementation of sampling rate conversion. Digital Filter Banks –Two-channel Quadrature Mirror Filter bank: Elimination of Aliasing, Condition for perfect reconstruction.

UNIT – IV **9**

Uniform and Two Channel Filter Banks and Sparse Signal Processing: Polyphase form of the QMF bank. Two channel QMF banks –M-Channel QMF Bank. Sparse Signal Processing: Sparse signals-Compressible signal -Over complete dictionaries -Coherence between the bases -Compressed sensing and signal reconstruction -Restricted isometric property.

UNIT – V **9**

Applications: Adaptive Filters: System Identification or System Modeling-Echo Cancellation in Data Transmission over Telephone Channels–Adaptive Noise Cancelling. Multirate Signal Processing: Subband Coding of Speech Signals. Biomedical Signal Processing: Selecting an Appropriate Filter – Removal of Artifacts in ECG – Adaptive Cancellation of the Maternal ECG to obtain Fetal ECG.

Lecture:45, Tutorial:15, Total: 60

REFERENCES:

1. Monson H. Hayes, "Statistical Digital Signal Processing and Modelling", Wiley India Edition, Georgia Institute of Technology–Atlanta, USA, 2013.
2. John G. Proakis and Dimitris G. Manolakis, "Digital Signal Processing–Principles, Algorithms and Applications", 4^{th} Edition, Pearson, Massachusetts Institute of Technology, Cambridge, USA, 2011.
3. Rangaraj M. Rangayyan, "Biomedical Signal Analysis A Case Study Approach", Wiley, University of Calgary, Canada, 2014.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	explain the various techniques in discrete time random signal process	Understanding (K2)
CO2:	analyze wiener and adaptive filters	Analyzing (K4)
CO3:	analyze the signals through multirate signal processing and uniform and two channel filter banks	Analyzing (K4)
CO4:	explain the concept of sparse signal processing	Understanding (K2)
CO5:	analyze the real time signals by applying advanced digital signal processing techniques	Analyzing (K4)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4
CO1	2	2		
CO2	3	3	2	2
CO3	3	3	2	2
CO4	2	2		
CO5	3	3	2	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT – Blooms Taxonomy

18CIT22 INDUSTRIAL AUTOMATION AND NETWORKING

L	T	P	Credit
3	0	0	3

Preamble	To provide a better solution for an industrial automation with suitable hardware modules and networking with suitable communication protocols.
Prerequisites	Digital Logic Circuits, Process Control, Control System

UNIT – I **9**

PLC and its Programming: Architecture – Ladder logic Vs Relay logic – Timer Functions - Counter Functions – Arithmetic Functions – Logic Functions – Comparison Functions - Program Control Instructions – Sequencer Instructions.

UNIT – II **9**

Distributed Control Systems: Advantages – Various architectures – Local Control Unit (LCU) – Operator Interface – Engineering interface – Types of DCS Displays – Development of Graphical User Interface (GUI).

UNIT – III **9**

Applications of PLC and DCS: Bottle Filling System – Material Handling System – Spray Painting System – Traffic light control. DCS in Power plants – Iron and Steel plants – Chemical plants – Cement plants – Pulp and Paper plants.

UNIT – IV **9**

Data Network Interfaces: EIA 232 / EIA 485/ EIA 422 interface standard – Media access protocol: TCP/IP – Bridges – Routers – Gateways – Standard ETHERNET Configuration.

UNIT – V **9**

Communication Protocols: Field bus: Architecture – Basic requirements of field bus standard – Field bus topology. Profibus: Protocol stack, communication model, Communication objects. AS interface – Device net – Industrial Ethernet

Total: 45

REFERENCES:

1. Webb John W., Reis Ronald A., "Programmable Logic Controllers: Principles and Applications", 3rd Edition, Prentice Hall, New Jersey, 2002.
2. Lucas Michal P., "Distributed Control Systems", Van Nostrand Reinhold Co., 1986.
3. Steve Mackay, Edwin Wright, Deon Reynders, "Practical Industrial Data Networks: Design, Installation and Troubleshooting", Elsevier, 2004.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	carryout the ladder logic programming using PLC	Applying (K3)
CO2:	describe the functional units of DCS	Understanding (K2)
CO3:	develop PLC and DCS in various applications for automation purpose	Applying (K3)
CO4:	interpret various data network interfaces for various purpose	Analyzing (K4)
CO5:	explain various communication protocols and their applications	Understanding (K2)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4
CO1	3	3	1	1
CO2	2	2		
CO3	3	3	1	1
CO4	3	3	2	2
CO5	2	2		

1 – Slight, 2 – Moderate, 3 – Substantial BT – Blooms Taxonomy

18CIC21 NON-LINEAR SYSTEM ANALYSIS AND CONTROL

L	T	P	Credit
3	0	2	4

Preamble	To investigate possible behaviors of nonlinear systems, investigate their stability, and to design control schemes.
Prerequisites	Control systems, Linear System Theory

UNIT – I **9**

Phase Plane Analysis: Behaviour of non-linear systems: Jump resonance, Sub-harmonic oscillation-Singular points-Phase plane analysis of linear and nonlinear systems - Construction of phase portraits using isoclines-Limit cycle analysis.

UNIT – II **9**

Describing Function Analysis: Typical non-linearities - Describing functions of typical nonlinearities - derivation of describing function for nonlinearities: relay, saturation. Review of Nyquist criterion for linear system-Nyquist stability criteria for non-linear system-Limit cycle oscillations-Accuracy of describing function method.

UNIT – III **9**

Lyapunov Stability Analysis: Nonlinear systems and equilibrium points - concepts of stability - linearisation and local stability-Lyapunov's direct method-Stability analysis of linear and non-linear systems-Construction of Lyapunov functions: Krasovski's theorem and Variable gradient method.

UNIT – IV **9**

Feedback Linearization and Sliding Mode Control: Feedback linearization and the canonical form- Input-Output linearization and Input-State linearization. Sliding surfaces-Filippov's construction-Direct implementations of switching control laws and continuous approximations - Applications: Inverted pendulum, ball and beam system.

UNIT – V **9**

Adaptive Control: Fundamentals-Model Reference Adaptive Control-Self Tuning Regulator- Direct and indirect adaptive control of linear systems - Neural Adaptive control of nonlinear systems - Applications: Inverted pendulum, ball and beam system.

Lecture:45, Practical:30, Total:75

List of Exercises / Experiments :

1. Obtain the time response of an armature controlled DC shunt motor by deriving state model in continuous domain. Discretize the state model and obtain discrete time response for a step voltage.
2. Derive a model and design a state feedback controller for a liquid level control system using MATLAB.
3. Design a feedback linearization controller for a liquid level control system using MATLAB.
4. Design a sliding mode controller for an inverted pendulum using MATLAB.
5. Design and implementation of a state feedback controller for CSTR process using MATLAB.

REFERENCES:

1.	Jean-Jacques Slotine and Weiping Li, "Applied Nonlinear Control", 1st Edition, Prentice-Hall, 1991.
2.	Hassan K. Khalil, "Nonlinear Systems", 3rd Edition, Prentice-Hall, 2002.
3.	Gang Feng and Rogelio Lozano, "Adaptive Control Systems", 1st Edition, Newnes Publisher, 1999.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	interpret the fundamental behaviours of non-linear systems	Understanding (K2)
CO2:	analyze non-linear systems in time and frequency domain	Analyzing (K4)
CO3:	apply the Lyapunov method for stability analysis for non-linear systems	Applying (K3)
CO4:	implement sliding mode controller for non-linear systems	Applying (K3)
CO5:	implement adaptive controller for non-linear systems	Applying (K3)
CO6:	perform the state space modeling of systems	Applying (K3), Precision (S3)
CO7:	execute the state response of systems	Analyzing (K4), Precision (S3)
CO8:	demonstrate the performance of controllers	Evaluating (K5), Precision (S3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4
CO1	2	2		
CO2	3	3	2	2
CO3	3	3	1	1
CO4	3	3	1	1
CO5	3	3	1	1
CO6	3	3	3	3
CO7	3	3	3	3
CO8	3	3	3	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT – Blooms Taxonomy

18MTC21 ROBOTICS ENGINEERING

(Common to Mechatronics, CADCAM & Control and Instrumentation Engineering branches)

L	T	P	Credit
3	0	2	4

Preamble	The course on Robotics Engineering is intended to provide a reasonable understanding of robotics and robot anatomy, the mathematics behind kinematics and dynamics of robot. It also involves controlling the robot motion using different control strategies.
Prerequisites	Bridge Course Mechanical and Applied Mathematics for Mechatronics

UNIT – I **9**

Introduction: History of robotics – Robot Anatomy – Robot specifications - Work space – Degree of freedom - Joint types - Types of robots – Precision of movements - End effectors – Dexterity - Robot applications.

UNIT – II **9**

Robot Kinematics: Descriptions: Position, Orientations and translation – Mapping: Changing from frame to frame – Operators: Translations, Rotation and Transformation - Homogeneous Transformation matrices - Forward and Inverse kinematics - Representation of links using Denavit - Hartenberg parameters.

UNIT – III **9**

Velocity and Static Force: Introduction - Linear and angular velocities of a rigid body - Velocity propagation – Derivation of Jacobian matrix for Serial manipulator – Singularities - Static force of serial manipulator.

UNIT – IV **9**

Robot Dynamics: Acceleration of a rigid body - Inertia of a link - Equations of motion for serial manipulators: Euler Lagrange formulation, Newton Euler formulation –– Inverse dynamics of serial manipulator.

UNIT – V **9**

Robot Control: Point to point and Continuous path motions – Joint trajectory Vs Cartesian trajectory – Trajectory planning – Trajectory following - Disturbance rejection – PD and PID control – Computer torque control - Adaptive control – Feedback linearization control.

List of Experiments:

1. Study the functions of ABB IRB 1410 industrial robot- components, drive system and end effectors.
2. Virtual reality robot programming for different tasks- Painting, Pick and place and switch off intruder alarm.
3. Virtual reality robot programming for different tasks- Stacking of blocks and Machining of billets.
4. Creation of Tool Centre Point (TCP) and Work Object using ABB IRB 1410 industrial robot.
5. Pick and place operation in teach mode using ABB IRB 1410 industrial robot.
6. Machine tending operation in teach mode using ABB IRB 1410 industrial robot.
7. Robot programming exercises - Point-to-point programming.
8. Robot programming exercises - Continuous path programming.
9. Robot programming exercises – Path planning in offline mode.
10. Vision based On-line Inspection and sorting of components using ABB IRB 1410 industrial robot.

Lecture: 45, Practical:30, Total: 75

REFERENCES / MANUALS / SOFTWARES:

1. Groover M.P., Weiss M., Magel R.N., Odrey N.G. and Dulta A., "Industrial Robotics, Technology, Programming and Applications", 2nd Edition, McGraw-Hill Companies, 2012.
2. Saeed B. Niku, "Introduction to Robotics: Analysis, Control, Applications", 2nd Edition, Wiley India Pvt. Ltd., 2012.
3. Craig John J., "Introduction to Robotics: Mechanics and Control", 4th Edition, Pearson/Prentice Hall Publication, 2018.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	interpret the industrial manipulator anatomy and estimate the gripping force of robot end effector	Applying (K3)
CO2:	develop the forward and inverse kinematics for serial manipulators	Applying (K3)
CO3:	formulate Jacobian matrix for velocity and static force analysis of serial manipulators	Applying (K3)
CO4:	formulate dynamic equations for serial manipulators	Applying (K3)
CO5:	apply the scheme of trajectory planning and control for manipulator motion control	Applying (K3)
CO6:	analyze the industrial robot work cell problems	Analyzing (K4), Manipulation (S2)
CO7:	develop robot programming through online /offline mode	Creating (K6), Precision (S3)
CO8:	develop an online inspection system using machine vision	Creating (K6), Precision (S3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4
CO1	2		2	2
CO2	2		3	3
CO3	2		3	3
CO4	2		2	2
CO5	2		3	3
CO6	2	3	2	2
CO7	3	3	2	2
CO8	3	3	2	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18COT21 WIRELESS SENSOR NETWORKS

(Common to Communication Systems, Control and Instrumentation Engineering, Computer Science and Engineering & Information Technology branches)

L	T	P	Credit
3	1	0	4

Preamble: This course will cover the most recent research topics in wireless sensor networks and IPV6 transition. Topics such as MAC layer and PHY layer functionalities, 6LoWPAN fundamentals, routing, mobility and other advanced topics are precisely covered.

Prerequisites: Wireless Networks

UNIT – I **9**

IEEE 802.15.4 PHY Layer: WSN Introduction, WPAN, network topologies, superframe structure, data transfer model, frame structure, slotted CSMA, IEEE 802.15.4 PHY: frequency range, channel assignments, minimum LIFS and SIFS periods, O-QPSK PPDU format, modulation and spreading. Simulation of data transfer model using Cooja simulator.

UNIT – II **9**

IEEE 802.15.4 MAC Layer: MAC functional description, MAC frame formats and MAC command frames, Simulation of WSN traffic model using Cooja simulator.

UNIT – III **9**

6LoWPAN Fundamentals: 6LoWPAN-Introduction, protocol stack, addressing, L2 forwarding, L3 routing, Header Compression, Fragmentation and Reassembly, Commissioning, Neighbor Discovery. Analyzing of sensor data exchange using Wireshark.

UNIT – IV **9**

6LoWPAN Mobility and Routing: Mobility: types, Mobile IPv6, Proxy MIPv6, NEMO, Routing: Overview, ROLL, border routing, RPL, MRPL, Edge Router Integration (Cooja simulation).

UNIT – V **9**

IPv6 Transition and Application Protocols: IPv4 Interconnectivity: IPv6 transition, IPv6-in-IPv4 tunneling, application protocols: design issues, MQTT-S, ZigBee CAP.

Lecture:45, Tutorial:15, Total: 60

REFERENCES:

1. “IEEE Standard for Local and metropolitan area networks, Part 15.4: Low-Rate Wireless Personal Area Networks (LR-WPANs)”, IEEE Computer Society, New York, 5 September 2011.
2. Shelby and Zach, "6LoWPAN : The Wireless Embedded Internet", 1st Edition, John Wiley & Sons Inc., Hoboken, New Jersey, 2009, ISBN 978-0-470-74799-5.
3. Holger Karl and Andreas Willig, “Protocols and architectures for wireless sensor networks”, John Wiley & Sons Inc., Hoboken, New Jersey, 2005, ISBN 978-0-470-09510-2.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	interpret the physical layer functionalities of IEEE 802.15.4 sensor devices	Understanding (K2)
CO2:	analyze MAC frame modeling of IEEE 802.15.4 sensor devices	Analyzing (K4)
CO3:	analyze 6LoWPAN architecture	Analyzing (K4)
CO4:	validate the routing protocol performance of 6LoWPAN devices	Evaluating (K5)
CO5:	apply IPV6 protocols for IoT applications	Applying (K3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4
CO1	3	3	1	1
CO2	3	3	2	2
CO3	3	3	2	2
CO4	3	3	3	3
CO5	3	3	1	1

1 – Slight, 2 – Moderate, 3 – Substantial BT – Blooms Taxonomy

18MSC21 MACHINE LEARNING TECHNIQUES

(Common to Computer Science and Engineering, Information Technology, Information Technology (Information Cyber Warfare) & Control and Instrumentation Engineering branches)

L	T	P	Credit
3	0	2	4

Preamble	Provides a concise introduction to the fundamental concepts of machine learning and popular machine learning algorithms.
Prerequisites	Nil

UNIT – I **9**

Supervised Learning: Definition of Machine Learning - Examples of Machine Learning Applications. Supervised Learning:Learning a Class from Examples - VC Dimension - PAC Learning - Noise - Learning Multiple Classes - Regression - Model Selection and Generalization - Dimensions of a Supervised Machine Learning Algorithm. Dimensionality Reduction: Introduction - Subset Selection – Principal Component Analysis- Feature Embedding - Factor Analysis.

UNIT – II **9**

Tree And Probabilistic Models: Learning with Trees – Decision Trees – Constructing Decision Trees – Classification and Regression Trees – Different ways to Combine Classifiers – Boosting – Bagging –– Gaussian Mixture Models – Nearest Neighbor Methods – Unsupervised Learning – K means Algorithm.

UNIT – III **9**

Multilayer Perceptrons: Introduction - The Perceptron - Training a Perceptron - Learning Boolean Functions - Multilayer Perceptrons - MLP as a Universal Approximator - Backpropagation Algorithm - Training Procedures - Tuning the Network Size - Dimensionality Reduction - Learning Time

UNIT – IV **9**

Kernel Machines: Introduction - Optimal Separating Hyperplane - Soft Margin Hyperplane - v-SVM - Kernal Trick - Vectorial Kernels - Defining Kernels - Multiple Kernel Learning - Multiclass Kernel Machines - One class Kernel Machines - Kernel Dimensionality Reduction.

UNIT – V **9**

Reinforcement Learning: Introduction - Single State Case-Elements of Reinforcement Learning - Model-Based Learning - Temporal Difference Learning - Generalization - Partially Observable States. Design of Machine Learning Experiments: Introduction - Factors, Response, and Strategy of Experimentation - Response Surface Design - Randomization, Replication, and Blocking - Guidelines for Machine Learning Experiments.

List of Exercises / Experiments :

1. Implementation of linear regression
2. Implementation of Decision tree
3. Implementation of k-means clustering
4. Implementation of k-NN
5. Implementation of Backpropagation algorithm
6. Comparison of linear regression and decision tree algorithm for the given dataset
7. Comparison of kernel functions of Support Vector Machine for the given dataset

Lecture:45, Practical:30, Total: 75

REFERENCES / MANUALS / SOFTWARES:

1. Ethem Alpaydin, "Introduction to Machine Learning", 3rd Edition, Prentice Hall of India, 2014.
2. Christopher Bishop, "Pattern Recognition and Machine Learning", 2nd Edition, Springer, 2011.
3. Willi Richert, Luis Pedro Coelho, "Building Machine Learning Systems with Python", 2nd Edition, Packt Publishing Ltd., 2015.

COURSE OUTCOMES: On completion of the course, the students will be able to		BT Mapped (Highest Level)
CO1:	illustrate the foundations of machine learning and apply suitable dimensionality reduction techniques for an application	Applying (K3)
CO2:	make use of supervised methods to solve the given problem	Applying (K3)
CO3:	apply neural networks to solve real world problems	Applying (K3)
CO4:	solve real world problems using kernel machines	Applying (K3)
CO5:	summarize the concepts of reinforcement learning and design machine learning experiments	Analyzing (K4)
CO6:	implement various supervised algorithms and evaluate the performance	Analyzing (K4), Precision (S3)
CO7:	implement the unsupervised algorithms and evaluate the performance	Analyzing (K4), Precision (S3)
CO8:	implement and compare the performance of different algorithms	Analyzing (K4), Precision (S3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4
CO1	3			
CO2	3			
CO3	3			
CO4	3			
CO5	3			
CO6	3			1
CO7	3			1
CO8	3			1

1 – Slight, 2 – Moderate, 3 – Substantial, BT – Blooms Taxonomy

18CIE01 OPTIMAL AND ADAPTIVE CONTROL

L	T	P	Credit
3	0	0	3

Preamble	This course covers the design of optimal controller for linear systems and the concepts of adaptive control for nonlinear systems
Prerequisites	Nonlinear system analysis and control

UNIT – I **9**

Optimal Control Formulation: Review of matrix theory, functionals of a single function and several functions-necessary conditions and boundary conditions. The performance measures for optimal control problems Hamiltonian approach-necessary conditions for optimal control- Linear regulator problem-infinite time regulator problem- Applications: DC motor, Inverted pendulum

UNIT – II **9**

Dynamic Programming: Principle of optimality - recurrence relation of dynamic programming for optimal control problem - dynamic programming application to discrete and continuous systems - Hamilton Jacobi Bellman equation.

UNIT – III **9**

System Identification: Review of adaptive control techniques - Model free adaptive control- Non-parametric methods of system identification: Transient analysis, Frequency analysis, correlation analysis. Parametric methods of system identification: Parameter estimation algorithm for linearly and nonlinearly parameterized systems.

UNIT – IV **9**

Model-Free Adaptive Control: Introduction - Dynamic linearization approach of discrete-time nonlinear systems-Model free adaptive control: compact-form dynamic linearization, partial-form dynamic linearization-Stability Analysis.

UNIT – V **9**

Adaptive Dynamic Programming: Problem formulation- Dynamic Programming algorithm for finite horizon problems with known states- Computational limitations- Approximate Dynamic Programming - neural networks for parametric approximation-neuro adaptive critic structure-applications: inverted pendulum, ball and beam system.

Total: 45

REFERENCES:

1. Dimitri P. Bertsekas, "Dynamic Programming and Optimal Control", Vol. I, 4^{th} Edition, Athena Scientific, 2017.
2. Zhongsheng Hou, Shangtai Jin, "Model Free Adaptive Control: Theory and Applications", CRC Press, 2016.
3. Desineni Subburam Naidu, "Optimal Control Systems", CRC Press, 2003.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	implement optimal controller for linear systems	Applying (K3)
CO2:	apply dynamic programming concepts for optimal control of systems	Applying (K3)
CO3:	interpret parametric and non parametric methods of system Identification	Understanding (K2)
CO4:	implement adaptive controller for model free systems	Applying (K3)
CO5:	apply adaptive dynamic programming concepts for nonlinear systems	Applying (K3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4
CO1	3	3	1	1
CO2	3	3	1	1
CO3	2	2		
CO4	3	3	1	1
CO5	3	3	1	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT – Blooms Taxonomy

18CIE02 ADVANCED INSTRUMENTATION SYSTEM DESIGN		
		L: 3, T: 0, P: 0, Credit: 3
Preamble	The objective of this course is to give deep knowledge in electronics devices and systems with a focus on sensor systems. It provides knowledge, methods, and tools for modeling and design of Instrumentation systems	
Prerequisites	Industrial Instrumentation , Electronics and digital design circuit	
UNIT – I		**9**
Principles of Analog Signal Conditioning: Signal level and bias changes, linearization, conversion, filtering and impedance matching, concept of loading - Passive circuits: Divider circuit, DC Bridge circuit, OP Amp circuits for instrumentation: Voltage follower, V/I, I/V, differential amplifier instrumentation amplifier, Differentiator, integrator, and linearization- Design guidelines.		
UNIT – II		**9**
Design of Signal Conditioning Circuits: Temperature transmitter, RTD, thermocouple, strain gauge- Design considerations.		
UNIT – III		**9**
Design of Control Valve: Valve capacity, valve sizing, pressure drop, cavitation and flashing, rangeability, Control valve selection factors- Control valve calibration- Digital Control valve design.		
UNIT – IV		**9**
Design of Analog Controllers: Electronic controller: Error detector, single mode controller, Composite mode controllers- Design of pneumatic controller – Design consideration.		
UNIT – V		**9**
Converters: ADC, DAC conversion, resolution and other characteristics. Design of a Microprocessor based Instrumentation System. Characteristics of digital data- Digitized value, Interfacing circuits and data acquisition system.		
		Total: 45

REFERENCES:

1. Johnson C. D., “Process Control Instrumentation Technology”, 8th Edition, Prentice Hall, 2006.
2. Norman A. Anderson, “Instrumentation for Process Measurement and Control”, CRC Press LLC, Florida, 1998.
3. Roy D. Choudhury, Shail B. Jain, “Linear Integrated Circuits”, 4th Edition, New AGE International Publishers, 2010.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	interpret the basic concept of analog circuit design for different problems	Understanding (K2)
CO2:	design of signal conditioning circuits for various sensors and transducer	Applying (K3)
CO3:	represent the design procedure of control valve	Understanding (K2)
CO4:	design and Implement the control circuit for both analog and pneumatic types	Applying (K3)
CO5:	develop the control design techniques in digital mode	Applying (K3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4
CO1	2	2		
CO2	3	3	1	1
CO3	2	2		
CO4	3	3	1	1
CO5	3	3	1	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT – Blooms Taxonomy

18CIE03 INSTRUMENTATION IN AUTOMOBILES AND BUILDING AUTOMATION

L	T	P	Credit
3	0	0	3

Preamble	To impart the concept of instrumentation in automobiles and automation in building.
Prerequisites	Control Systems, Transducers and Smart Instruments

UNIT – I **9**

Basics of Electronic Engine Control: Motivation for Electronic Engine Control - Electronic Engine Control System - Engine Mapping - Electronic Fuel Control System: Engine Control Sequence, Closed Loop Control, Open Loop Mode - Analysis of Intake Manifold Pressure - Electronic Ignition.

UNIT – II **9**

Sensors and Actuators for Automotive Control System: Automotive Control System Applications of Sensors and Actuators - Air Flow Rate Sensor - Engine Crankshaft Angular Position Sensor - Throttle Angle Sensor - Temperature Sensors - Sensors for Feedback Control - Automotive Engine Control Actuators.

UNIT – III **9**

Vehicle Motion Control: Typical Cruise Control System - Cruise Control Electronics: Stepper Motor based Actuator - Vacuum Operated Actuator - Antilock Braking System - Electronic Suspension System - Electronic Steering Control - Global Positioning System

UNIT – IV **9**

Introduction to Building Automation: Building Automation - Control Devices - Control Signals - Control information - Control Logic - Building Systems - Electrical Systems Control Devices - Electrical Systems Control Applications - Lighting Systems Control Devices -Lighting Systems Control Applications.

UNIT – V **9**

Applications of Building Automation Systems: HVAC systems, Security System, Elevator System, Automated Building Operation.

Total: 45

REFERENCES:

1. William Ribbens, "Understanding Automotive Electronics - An Engineering Perspective", 7th Edition, Butterworth-Heinemann, 2013.
2. Reinhold A. Carlson, Robert A. Di Giandomenico, "Understanding Building Automation Systems (Direct Digital Control, Energy Management, Life Safety, Security, Access Control, Lighting, Building Management Programs)," R.S. Means Company Inc., 1991.
3. John T. Wen, Sandipan Mishra, "Intelligent Building Control Systems- A Survey of Modern Building Control and Sensing Strategies", 1st Edition, Springer International Publishing, 2018.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	comment on the basic concepts of Electronic Engine Control and building	Understanding (K2)
CO2:	summarize Sensors and Actuators used for Automotive Control System	Understanding (K2)
CO3:	interpret different vehicle motion control mechanisms	Understanding (K2)
CO4:	prepare the automation systems in HVAC, security, elevator and automated building operating systems	Applying (K3)
CO5:	integrate the automation systems in automobiles and building operation systems	Analyzing (K4)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4
CO1	2	2		
CO2	2	2		
CO3	2	2		
CO4	3	3	1	1
CO5	3	3	2	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT – Blooms Taxonomy

18CIE04 BIOPROCESS INSTRUMENTATION AND CONTROL

L	T	P	Credit
3	0	0	3

Preamble	The course depicts the fulfillment of learning skills from instrumentation, in the field of Bioprocessing. Biosensors, Bioreactors, Control of Industrial Fermentations, Food Biotechnology and Process Control concepts were introduced accordingly.
Prerequisites	Transducer Engineering, Process Control and Control Systems.

UNIT – I **9**

Overview of Bioprocessing: Historical developments of bioprocessing technology-Overview of traditional and modern applications of biotechnology- Interdisciplinary approach to bioprocessing- Outlines of integrated bioprocess-Unit operations in bioprocess.

UNIT – II **9**

Biosensors: Introduction- Biosensors in process monitoring- Transduction Methods: Amperometric, Potentiometric, Capacitance and Impedance, Thermal, Optical Fiber Biosensors, Surface Plasmon Resonance, Piezoelectric, Mechanical - Amperometric biosensors based on redox enzymes - Amperometric glucose biosensors for blood glucose monitoring: Diabetes Mellitus, Glucose Meter: Enzymes used in glucose biosensors, mediated electrochemistry, electrochemical measurement, Assay protocol.

UNIT – III **9**

Bioreactors: Component parts of bioreactors - Component parts of a typical vessel - Peripheral parts and accessories: peristaltic pumps, medium feed pumps and reservoir bottles, rotameter/gas supply, sampling device - Bioreactor instrumentation: Digital controllers - embedded microprocessor, process controller, direct computer control - Common measurement and control systems: speed control, temperature control, control of gas supply, control of pH, control of dissolved oxygen, antifoam control, feed control, factors influencing chemostat operation, Fed-Batch Fermentation.

UNIT – IV **9**

Control of Industrial Fermentations: Requirement for control: Microbial growth, nature of control, control loop strategy – Sensors: historical perspective, typical fermentation sensors, control action – Controllers: Types of control, control algorithms, PID - Design of a Fermentation Control System: Control system objectives, fermentation computer control system architecture, fermentation plant safety - Other Advanced Fermentation Control Options: knowledge-based systems, artificial neural networks, metaheuristic algorithms, modeling - Recent Trends in Fermentation Control: New sensor technology, software sensors, expansion of the capability of DDC instrumentation, use of common communication protocols, use of databases for storage bioprocess data.

UNIT – V **9**

Food Biotechnology and Process Control: Fermentation technology: Theory, equipment, commercial food fermentations, effects on food – Process control: Sensors, controllers and PLCs, neural networks, fuzzy logic and robotics, production control.

Total: 45

REFERENCES:

1. Rao D.G., “Introduction to Biochemical Engineering”, Chemical Engineering Series, Tata McGraw Hill, 2007.
2. El-Mansi E.M.T., Bryce C.F.A, Dahhou B., Sanchez S., Demain A.L., and Allman A.R., “Fermentation Microbiology and Biotechnology”, 3rd Edition, CRC Press, 2012.
3. Fellows P.J., “Food Processing Technology-Principles and Practice”, 3rd Edition, Woodhead Publishing Ltd., 2015.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	relate the basic concepts of bioprocessing in terms of developments, applications, approach and unit operations	Understanding (K2)
CO2:	interpret the concepts of biosensors and applying it for practical problems	Applying (K3)
CO3:	infer various parts of bioreactors and examine the common measurement and control of various parameters	Analyzing (K4)
CO4:	use a fermentation control system based on industrial perspective	Applying (K3)
CO5:	influence fermentation technology for food processing and its post-processing operations	Evaluating (K5)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4
CO1	2	2		
CO2	3	3	1	1
CO3	3	3	2	2
CO4	3	3	1	1
CO5	3	3	3	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT – Blooms Taxonomy

18CIE05 DIGITAL INSTRUMENTATION

L	T	P	Credit
3	**0**	**0**	**3**

Preamble	To understand the principles and concepts of digital instruments and their applications.
Prerequisites	Digital Logic Circuits, Microprocessors and Microcontrollers

UNIT – I **9**

D/A and A/D Converters: D/A converters – binary weighted and R-2R ladder type – D/A accuracy and resolution – A/D converters counter ramp, successive approximation, simultaneous, dual – slope A/D converters –A/D accuracy and resolution – sample and hold circuit.

UNIT – II **9**

Frequency and Time Measurement: Frequency counter – decimal counting and display – multiplexing displays – time base circuitry – counting input events – frequency ratio measurement – period measurement – time interval and pulse width measurement – phase measurement – scaling – accuracy – errors – counting errors.

UNIT – III **9**

Digital Voltmeters and Multimeters: Staircase–ramp and dual slope DVM – successive approximation. DVM – sources of error – quantizing error –automation in voltmeters – automatic polarity indication, ranging and zeroing – fully automatic instrument –digital multimeters – current to voltage and resistance to voltage conversion – AC and RMS measurements – Q–measurement.

UNIT – IV **9**

Oscilloscopes and Recorders: Digital storage oscilloscope – principles and instrumentation – spectrum analyzer – digital recorders and plotters.

UNIT – V **9**

Microcomputer Based Instruments: Microcomputer compatible D/A and A/D converters – handshake input and output – interfacing keyboard and display – common bus and data communication standards – parallel bus standard, the HPIB or IEEE 488 – serial bus standard – RS 232C and modems – interfacing CRT display – CRT character generator – CRT controllers.

Total: 45

REFERENCES:

1. Bouwens A.J., “Digital Instrumentation”, McGraw Hill, 1984.
2. Helfrick A.D. and Cooper W.D., “Modern Electronic Instrumentation and Measurement Techniques”, 3rd Edition, Prentice Hall India, 1990.
3. Hall D.V., “Microprocessors and Digital Systems”, 3rd Edition, McGraw Hill, 1983.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	distinguish the characteristics of A/D and D/A converters	Understanding (K2)
CO2:	explain the principles of frequency and time measurements	Understanding (K2)
CO3:	relate the concept of digital voltmeters and multimeters	Understanding (K2)
CO4:	experiment with oscilloscopes and recorders	Applying (K3)
CO5:	design microcomputer based digital instruments	Applying (K3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4
CO1	2	2		
CO2	2	2		
CO3	2	2		
CO4	3	3	1	1
CO5	3	3	1	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT – Blooms Taxonomy

18CIE06 PIPING AND INSTRUMENTATION DESIGN IN PROCESS INDUSTRIES		
	L T P Credit 3 0 0 3	
Preamble	To study the concepts of Piping and Instrumentation diagram (P&ID) symbols, Process flow sheets, Process Flow diagram and to apply P&IDs for different stages of Process.	
Prerequisites	Industrial Instrumentation and Process Control	
UNIT – I		**9**
Process Flow Diagram: Types of Flow sheets, Flow sheet presentation, Flow sheet symbols, Line symbols and designation, Block Flow Diagram (BFD) - Process Flow Diagram (PFD) - PFD symbols.		
UNIT – II		**9**
Piping and Instrumentation Diagram: Piping and Instrumentation (P&I) Diagram objectives, Industry Codes and Standard. P& I D Symbols - Line numbering - Line Schedule - P & ID development - Typical Stages of P & ID - P &ID for Process Vessels, Absorber and Evaporator.		
UNIT – III		**9**
Loop Diagram: Loop Diagrams- Pneumatic Loop – Electronic Loop – Loop diagram Terminal symbols – Loop diagram for Pressure Control – Loop Diagram for Flow Control.		
UNIT – IV		**9**
Control System for Process Operation: Control systems for Reactors, Dryers, Distillation column and Heat exchangers.		
UNIT – V		**9**
Plant Instrumentation: Applications of P&ID in design stage – Construction stage – Commissioning stage – Operating stage – Revamping stage. Application of P&I diagrams in HAZOPS and Risk analysis.		
		Total: 45

REFERENCES:

1.	Ernest E. Ludwig, “Applied Process Design for Chemical and Petrochemical Plants Vol-I”, 4th Edition, Gulf Publishing Company, Houston, 2007.
2.	Max S. Peters and Timmerhaus K.D., “Plant Design and Economics for Chemical Engineers”, 5th Edition, McGraw Hill Inc., New York, 2011.
3.	Frederick A. Meier and Clifford A. Meier, “Instrumentation and control system documentation”, 1st Edition, ISA, USA, 2004.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	apply the concept of Piping and Instrumentation Diagram and Process Flow diagram	Applying (K3)
CO2:	organize and document the Instrument symbols and P&ID symbols for various Processes	Analyzing (K4)
CO3:	develop loop diagrams for pressure, flow and level control loops	Applying (K3)
CO4:	construct P&IDs for control loops in Reactors, Dryers, Distillation column and Heat exchangers	Applying (K3)
CO5:	build P&ID in different design stages of processes	Applying (K3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4
CO1	3	3	1	1
CO2	3	3	2	2
CO3	3	3	1	1
CO4	3	3	1	1
CO5	3	3	1	1

1 – Slight, 2 – Moderate, 3 – Substantial , BT – Blooms Taxonomy

18CIE07 APPLIED INDUSTRIAL INSTRUMENTATION

L	T	P	Credit
3	0	0	3

Preamble	This subject introduces the P&I diagrams for various equipment, Measuring Instruments, Safety aspects and calibration techniques used in industries.
Prerequisites	Industrial Instrumentation

UNIT – I | **9**

Piping and Instrumentation Diagrams: Application to Industries, identification system guidelines, instrument index, loop identification number, identification letter tables, instrument line symbols, measurement and control devices - and/or function symbols, multipoint, multifunction, and multivariable devices and loops - functional diagrams and function symbols: ISA functional diagramming, Equivalent P&ID Loop, Functional Instrument and Electrical Diagrams, Functional Diagramming Symbols - P&I Diagrams for rotating and static equipments.

UNIT – II | **9**

Miscellaneous Instrumentation: Boroscopes – Linear and angular position detection –Machine vision technology – noise sensors – proximity sensors and limit switches, Tachometers and angular speed sensors – Thickness and dimension measurement – shock analysis - weighing systems – weight sensors.

UNIT – III | **9**

Instrument Installation: Installation documentation, safety in design, pipe and tube material, Electrical Installations in Potentially Explosive Locations, installation of head flow meters.

UNIT – IV | **9**

Calibration: Calibration of pressure and temperature sensors, hysteresis, automatic calibration instrument, calibration of smart instruments. Testing: Testing of temperature, pressure sensors, response time testing, and LCSR testing.

UNIT – V | **9**

Safety Instrumentation: Electrical and intrinsic safety, Excess flow and regular check valves, Explosion suppression and deluge systems, Flame arrestors, conservation vents and emergency vent Flame, fire, smoke, leak and metal detectors, Relief valves and rapture disks, start-up and shutdown interlocks.

Total: 45

REFERENCES:

1. Bela G. Liptak, "Process Measurement and Analysis", Vol-I, 4th Edition, CRC Press, 2003.
2. Considine D.M., "Hand book of Applied Instrumentation", Tata McGraw-Hill, New Delhi, 1993.
3. William G. Andrew, Williams H.B., "Applied Instrumentation in the Process Industries: Engineering Data and Resource Material", Gulf Publishing Company, 1982.

COURSE OUTCOMES: On completion of the course, the students will be able to		BT Mapped (Highest Level)
CO1:	execute the P&I diagrams of the instruments used in process industries	Understanding (K2)
CO2:	explain the concepts of measuring Instruments in industries	Understanding (K2)
CO3:	interpret the installation techniques of various measuring instruments in industries	Understanding (K2)
CO4:	implement the calibration and testing procedure of temperature and pressure sensing devices	Applying (K3)
CO5:	identify the causes of hazards and apply the concepts of safety in industries	Applying (K3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4
CO1	2	2		
CO2	2	2		
CO3	2	2		
CO4	3	3	1	1
CO5	3	3	1	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT – Blooms Taxonomy

18MTE13 MEMS DESIGN

(Common to Mechatronics, CADCAM, Engineering Design, VLSI Design, Applied Electronics, Power Electronics and Drives & Control and Instrumentation Engineering branches)

L	T	P	Credit
3	0	0	3

Preamble: This course equips the students to understand the concepts of Micro mechatronics and apply the knowledge of micro fabrication techniques for various applications.

Prerequisites: Sensors and Instrumentation and Bridge course mechanical

UNIT – I **9**

Materials for MEMS and Scaling Laws: Overview - Microsystems and microelectronics - Working principle of Microsystems - Si as a substrate material - Mechanical properties - Silicon compounds - Silicon piezo resistors - Gallium arsenide - Quartz-piezoelectric crystals - Polymer - Scaling laws in Miniaturization.

UNIT – II **9**

Micro Sensors, Micro Actuators: Micro sensors - Micro actuation techniques - Micro actuators – Micromotors – Microvalves – Micro grippers – Micro accelerometer: introduction, types, actuating principles, design rules, modeling and simulation, verification and testing, applications.

UNIT – III **9**

Mechanics for Microsystem Design: Static bending of thin plates - Mechanical vibration - Thermo mechanics - Thermal stresses - Fracture mechanics - Stress intensity factors, fracture toughness and interfacial fracture mechanics-Thin film Mechanics-Overview of Finite Element Stress Analysis.

UNIT – IV **9**

Fabrication Process and Micromachining: Photolithography - Ion implantation - Diffusion – Oxidation – CVD - Physical vapor deposition - Deposition by epitaxy - Etching process- Bulk Micro manufacturing - Surface micro machining – LIGA –SLIGA.

UNIT – V **9**

Micro System Design, Packaging and Applications: Design considerations - Process design - Mechanical design – Mechanical Design using Finite Element Method-Micro system packaging – Die level - Device level - System level – Packaging techniques - Die preparation - Surface bonding - Wire bonding – Sealing - Applications of micro system in Automotive industry: Bio medical, Aerospace and Telecommunications – CAD tools to design a MEMS device.

Total: 45

REFERENCES:

1. Tai-Ran Hsu, "MEMS and Microsystems Design and Manufacture", Tata McGraw-Hill, New Delhi, 2008.
2. Mohamed Gad-el-Hak, "The MEMS Handbook", CRC Press, 2009.
3. Bao M.H., "Micromechanical Transducers: Pressure sensors, accelrometers, and gyroscopes", Elsevier, New York, 2000.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	interpret the concepts of MEMS materials and scaling laws	Remembering (K1)
CO2:	explain the principles of micro sensors and actuators	Understanding (K2)
CO3:	apply the mechanics for micro system design	Applying (K3)
CO4:	design and fabrication of microsystem	Applying (K3)
CO5:	design of microsystem packaging and application	Applying (K3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4
CO1			2	
CO2	1		2	
CO3	2	1	2	1
CO4	2	2	2	1
CO5	2	1	2	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18CIE08 SECURITY FOR SCADA SYSTEM

L	T	P	Credit
3	0	0	3

Preamble	To examine SCADA system threats and vulnerabilities, the emergence of protocol standards, and to know how security controls can be applied to ensure the safety of industrial infrastructures.
Prerequisites	Industrial automation and Networking

UNIT – I **9**

SCADA Systems in the Critical Infrastructure: Review of SCADA System Architecture and applications – overview of SCADA System Security Issues - SCADA and IT Convergence - Conventional IT Security and Relevant SCADA Issues - SCADA System Desirable Properties - Employment of SCADA Systems: Petroleum Refining - The Basic Refining Process - Possible Attack Consequences.

UNIT – II **9**

Evolution of SCADA Protocols: Review of the OSI Model and TCP/IP Model - SCADA Protocols: The MODBUS Model - The DNP3 Protocol - UCA 2.0 and IEC61850 Standards - Controller Area Network - Control and Information Protocol - DeviceNet - ControlNet - EtherNet/IP - FFB 59 - Profibus.

UNIT – III **9**

Security Implications of SCADA Protocols: Firewalls: Packet - Filtering Firewalls - Stateful Inspection Firewalls - Proxy Firewalls. Demilitarized Zone: Single Firewall DMZ - Dual Firewall DMZ. General Firewall Rules for Different Services - Virtual Private Networks.

UNIT – IV **9**

SCADA Vulnerabilities and Attacks: SCADA Risk Components: Risk Management Components - Assessing the Risk - Mitigating the Risk. SCADA Threats - SCADA Attack Routes - Typical Attacker Privilege Goals.

UNIT – V **9**

SCADA Security Methods and Techniques: SCADA Security Mechanisms - Improving Cyber security of SCADA Networks - Implementing Security Improvements SCADA Intrusion Detection Systems - Types of Intrusion Detection Systems - Network-Based and Host-Based IDS - Signature-Based and Anomaly-Based IDS- SCADA Audit Logs.

Total: 45

REFERENCES:

1. Robert Radvanovsky and Jacob Brodsky, “Handbook of SCADA/Control Systems Security”, 2nd Edition, CRC Press, 2016.
2. Eric Knapp, Joel Thomas Langill, “Industrial Network Security”, 2nd Edition, Syngress (Elsevier), 2014.
3. Ronald L. Krutz, “Securing SCADA Systems”, John Wiley & Sons, 2005.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	summarize the general security issues in SCADA systems	Understanding (K2)
CO2:	analyze the different SCADA protocols for automation	Applying (K3)
CO3:	examine the various security implications of SCADA protocols	Analyzing (K4)
CO4:	analyze the significance of SCADA risk and threat components	Analyzing (K4)
CO5:	outline the SCADA security methods and techniques	Understanding (K2)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4
CO1	2	2		
CO2	3	3	1	1
CO3	3	3	2	2
CO4	3	3	2	2
CO5	2	2		

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18CIE09 ROBUST CONTROL

L	T	P	Credit
3	0	0	3

Preamble	This course covers the internal stability analysis of interconnected systems, robust stability and robust performance.
Prerequisites	Linear System Theory

UNIT – I **9**

Introduction: Introduction to concepts of model uncertainty: parametric, dynamic uncertainty. Fundamental concept of robustness-relationship between physical systems and mathematical models. Mathematical background: norms for vectors, matrices, signals, and systems. Singular value decomposition - application to perturbation analysis.

UNIT – II **9**

Robustness Problems: Linear fractional transformations and canonical forms-performance measured via (induced) norms-robust stability and performance problems. Solution of SISO robustness problems.

UNIT – III **9**

Analysis of Robustness: Stability analysis- gamma stability- testing sets- Kharitonon's theorem- stability radius-structured singular value for robustness analysis of MIMO systems.

UNIT – IV **9**

Computer- Aided Analysis Techniques: Conversion of robustness problems to canonical MΔform-small gain theorem and approximate computation of μ via efficient upper and lower bounds-computer aided tools for μ analysis based on the μ Tools Matlab toolbox.

UNIT – V **9**

Synthesis and Controller Design: Optimal controller design: H2 and H∞ optimal control-scaled H∞ optimal control problems and μ synthesis - computer aided tools to implement D, G-K iteration for advanced controller design. Design case studies: Inverted pendulum, CSTR.

Total: 45

REFERENCES:

1. Mackenoth U., "Robust Control Systems", Springer, Verlag, London 2010.
2. Zhon K. and John C. Doyle, "Essentials of Robust Control", PHI, 1998.
3. Bhattacharya S.P. and Chapellat H., "Robust Control - The Parametric Approach", Prentice Hall, 1995.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	explain the mathematical foundations of robust control	Understanding (K2)
CO2:	carryout the robust performance of SISO systems	Applying (K3)
CO3:	execute the robust stability of SISO and MIMO systems	Applying (K3)
CO4:	interpret the computer aided tools for robust control analysis	Understanding (K2)
CO5:	implement robust control algorithms for non linear systems	Applying (K3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4
CO1	2	2		
CO2	3	3	1	1
CO3	3	3	1	1
CO4	2	2		
CO5	3	3	1	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18CIE10 DIGITAL SYSTEM AND LOGIC SYNTHESIS

L	T	P	Credit
3	0	0	3

Preamble	To impart the knowledge of digital design and logic synthesis for control circuits
Prerequisites	Digital Logic Circuits

UNIT – I **9**

Sequential Circuit Design: Analysis of clocked synchronous sequential circuits and modeling- State diagram, state table, state table assignment and reduction-Design of synchronous sequential circuits, design of iterative circuits-ASM chart and realization using ASM.

UNIT – II **9**

Asynchronous Sequential Circuit Design: Analysis of asynchronous sequential circuit – Flow table reduction – Races – State assignment-Transition table and problems in transition table- Design of asynchronous sequential circuit-Static, dynamic and essential hazards – Designing vending machine controller.

UNIT – III **9**

Synchronous Design using Programmable Devices: Programming logic device families: FPGA – Configurable Logic Blocks- Logic Cell Array- Inputs/Outputs Blocks– Programmable Interconnect point-Switching Matrix – Xilinx XC 4000 series and Virtex FPGA.

UNIT – IV **9**

System Design using VHDL: VHDL operators – Arrays – Concurrent and sequential statements – Packages-Data flow– Behavioral – Structural modeling – Compilation and simulation of VHDL code – Realization of combinational and sequential circuits using HDL – Design of simple microprocessor

UNIT – V **9**

Threshold Logic in Digital Design: Introduction-The threshold element-construction of threshold gates-implementation of Boolean functions using threshold gates- multigate systems.

Total: 45

REFERENCES:

1. Donald D. Givone, “Digital Principles and Design”, 1st Edition, Tata McGraw-Hill, 2003.
2. Charles H. Roth Jr, “Digital Systems Design using VHDL”, Thomson Learning, 2004.
3. Manjita Srivastava, Mahesh C. Srivastava, Atul K. Srivastava, “Digital Design: HDL-Based Approach”, 1st Edition, Cengage Learning, 2010.

COURSE OUTCOMES: On completion of the course, the students will be able to		BT Mapped (Highest Level)
CO1:	design synchronous sequential circuits	Applying (K3)
CO2:	design asynchronous sequential circuits	Applying (K3)
CO3:	develop programming for digital circuits with VHDL	Applying (K3)
CO4:	implement logics in FPGA	Applying (K3)
CO5:	construct threshold for logic gates	Applying (K3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4
CO1	3	3	1	1
CO2	3	3	1	1
CO3	3	3	1	1
CO4	3	3	1	1
CO5	3	3	1	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18CIE11 COMPUTER VISION AND IMAGE PROCESSING

L	T	P	Credit
3	0	0	3

Preamble	To introduce the concepts needed to understand the image signals, from their acquisition until their processing, through the important questions of signal representation and approximation occurring during data transmission or interpretation.
Prerequisites	Digital Image Processing

UNIT – I **9**

Introduction: A simple Image Model-Elements of Digital Image Processing-Applications of Digital image processing-Elements of visual perception: luminance, brightness, contrast, hue, saturation, Mach band effect, Simultaneous contrast, Theory of 2D Sampling. **Image Transforms:** Need for image transforms-2D: DFT, DST, DCT, HAAR, KL, SVD and Wavelet transforms and problems.

UNIT – II **9**

Image Enhancement: Introduction – Enhancement by point processing – Spatial filtering: smoothing and sharpening filters-Automatic Image Enhancement-Enhancement in frequency domain: low pass, high pass and homomorphic filtering - Image Enhancement using Differential Evolution. **Image Restoration:** Degradation model, Algebraic approach to Restoration: Unconstrained and Constrained restoration, Inverse filtering: Formulation, Removal of blur caused by Uniform Linear Motion, Wiener filter-Automatic Image Restoration.

UNIT – III **9**

Image Segmentation: Classification of image-segmentation techniques – Region approach to image segmentation – Clustering techniques-– Image segmentation based on thersholding - Active contour - Watershed transformation – Texture based segmentation — Atlas based segmentation-Wavelet based segmentation-Compressed Sensing: Introduction- Image and its processing – problems - Energy Based methods of image processing-Real time object detection. **Mathematical Morphology:** Structuring elements – Standard binary morphological operations: Erosion, dilation, opening and closing - Hit (or) miss transforms.

UNIT – IV **9**

Image Compression: Need for image compression – Run-length coding - Huffman coding - Arithmetic coding – Transform-based compression -Vector quantization - Block Truncation Coding – Wavelet based image compression-New Trends in Image Data Compression. **Compressed Sensing:** Introduction- Image and its processing – problems - Energy Based methods of image processing-Real time application in Compressed Sensing.

UNIT – V **9**

Image Registration: Registration: Preprocessing, Feature selection: points, lines, regions and templates. Feature correspondence: Point pattern matching, Line matching, Region matching, and Template matching. Transformation functions: Similarity transformation and Affine transformation.**Image Fusion:** Introduction - Pixel Fusion, Multiresolution based fusion: Wavelet fusion. **Applications:** IMAQ Vision: Pattern matching, Instrument readers,Real time detection of object on webcam.

Total: 45

REFERENCES:

1. Gonzalez Rafel C. and Woods Richard E., “Digital Image Processing”, 2nd Edition, Prentice Hall, New York, 2006.
2. Jayaraman S., Esakkirajan S. and Veerakumar T., “Digital Image Processing”, 1st Edition, Tata McGraw-Hill, New Delhi, 2009.
3. Soman K.P. and Ramanathan R., “Digital Signal and Image Processing – The Sparse Way”, 1st Edition, ISA Publishers, Amrita University, Coimbatore, 2012.

COURSE OUTCOMES: On completion of the course, the students will be able to		BT Mapped (Highest Level)
CO1:	carryout the image formation and the role of human visual system in perception of gray and color images	Applying (K3)
CO2:	predict image processing techniques in both the spatial and frequency domains using various transform techniques	Understanding (K2)
CO3:	find knowledge in real time detection of object in image segmentation	Applying (K3)
CO4:	interpret the new trends in image compression and compressed sensing using spatial and spectral domains	Applying (K3)
CO5:	apply the various concepts in image registration and fusion	Applying (K3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4
CO1	3	3	1	1
CO2	2	2		
CO3	3	3	1	1
CO4	3	3	1	1
CO5	3	3	1	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18CIE12 INDUSTRIAL DRIVES AND CONTROL		
		L: 3, T: 0, P: 0, Credit: 3

L	T	P	Credit
3	0	0	3

Preamble	To understand the principle and characteristics of controlled DC and AC Motor drives
Prerequisites	Electrical Machines

UNIT – I **9**

Phase Controlled DC Motor Drives: Single phase controlled converter-Three phase controlled Converter with Freewheeling, Converter configuration for a Four quadrant DC Motor Drive, Two quadrant Three Phase Converter Controlled DC Motor Drive, Two quadrant DC Motor Drive with Field Weakening, Converter selection and Characteristics.

UNIT – II **9**

Chopper Controlled DC Motor Drives: Principles of operation of chopper, Four quadrant chopper fed DC drives, Chopper for Inversion, Closed loop operation of Speed and Current controlled chopper fed DC drives, Applications: Forklift trucks, Hoists and Elevators.

UNIT – III **9**

Converter Fed AC Drives: VSI fed Induction motor drives, Braking and multi quadrant operation of VSI fed induction motor drives, Variable frequency control from a current sources, Closed loop control of CSI fed Induction motor drives, Self controlled synchronous motor drive employing load commutated thyristor inverter, Compare VSI and CSI drives performance.

UNIT – IV **9**

Control and Estimation of Induction Motor Drives: Induction motor control with small signal model, Open loop V/F control, Speed control with slip regulation, Speed control with torque and flux control, Adaptive control: Self tunning control- Sliding trajectory control of a vector drive.

UNIT – V **9**

Case Study: Solar powered pump drives, Battery powered vehicles, Electric Traction Services, Calculation of traction drive rating and energy consumption, Conventional dc and ac traction drives, Diesel Electric Traction systems.

Total: 45

REFERENCES:

1. Bose B.K., "Power Electronics and Motor Drives-Advances and Trends", 1st Edition, IEEE Press, 2006.
2. Gopal K. Dubey, "Fundamentals of Electrical Drives", 2nd Edition, Narosa Publishing House, 2018.
3. Buxbaum A. Schierau, and Staughen K., "A design of control systems for DC drives", 1st Edition, Springer-Verlag, Berlin, 1990.

COURSE OUTCOMES: On completion of the course, the students will be able to		BT Mapped (Highest Level)
CO1:	illustrate the selection and characteristics of converter fed DC drives	Applying (K3)
CO2:	construct the applications of chopper fed DC drives	Applying (K3)
CO3:	distinguish the characteristics of various Industrial AC drives	Analyzing (K4)
CO4:	infer suitable control and estimation techniques in AC drives	Analyzing (K4)
CO5:	demonstrate various types of electrical drive applications	Applying (K3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4
CO1	3	3	1	1
CO2	3	3	1	1
CO3	3	3	2	2
CO4	3	3	2	2
CO5	3	3	1	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom’s Taxonomy

18CIE13 EMBEDDED FPGA BASED CONTROL DESIGN

L	T	P	Credit
3	0	0	3

Preamble	Discuss the various aspects of FPGA interfacing with examples and sample codes giving an overview of VLSI technology, digital circuits design with Verilog, programming, components with real-world interfacing example
Prerequisites	Digital Logic Circuits

UNIT – I **9**

Elements of Embedded FPGA Design: Abstraction Level – Embedded System Design Flow – Design Tools. ALTERA's Cyclone FPGA: Logic Array Blocks, Logic Elements, Interconnect, Embedded Memory, Global Clock Network, I/O structure.

UNIT – II **9**

Verilog HDL: Basic Structure of Verilog – Modules, Ports, Variables, Logic Value System, Data Types. Gate Level Model – Dataflow Model –Behaviour Model – Switch Level Model – Tasks and Functions.

UNIT – III **9**

Design of Utility Hardware Cores: Library Management – Basic I/O Device Handling – Frequency Dividers – SSD – LCD Display – Keyboard Interface Logic– VGA Interface Logic. HDL Simulation and Synthesis – Design Prototype – Mixed level design with QUARTUS II.

UNIT – IV **9**

Embedded – FPGA System Development Environment: NIOS II Processor– Configurability features of NIOS II, Processor Architecture, Instruction Set- Alternative cores. System on a Programmable Chip (SOPC) builder overview – Architecture– Functions of SOPC builder, Integrated Development Environment (IDE).

UNIT – V **9**

Embedded FPGA – Control Design: Embedded Design Steps: Processor selection – Interfacing – Developing Software. Filter design: Filter concepts – FIR filter Hardware Implementation – FIR Embedded Implementation – Building the FIR Filter. Microcontroller – System Platform, Microcontroller Architecture. Case Studies: Automated Meter Reading System; Digital Camera.

Total: 45

REFERENCES:

1. Zainalabedin Navabi, **"**Embedded core design with FPGAs", 1st Edition, Tata McGraw Hill, 2008.
2. Samir Palnitkar, "Verilog HDL: A Guide to Digital Design and Synthesis", 3rd Edition, Pearson Education, New Delhi, 2006.
3. Ronald Sass and Andrew G. Schmidt, **"**Embedded Systems Design with Platform FPGAs: Principles and Practices**",** Morgan Kuafmann – Elsevier Publisher, 2010.

COURSE OUTCOMES: On completion of the course, the students will be able to		BT Mapped (Highest Level)
CO1:	explain the essential elements of embedded FPGA design	Understanding (K2)
CO2:	implement FPGA programming for digital structures	Applying (K3)
CO3:	carry out interface with other hardware cores using modern EDA tools	Applying (K3)
CO4:	classify FPGA systems from both hardware and software perspectives	Understanding (K2)
CO5:	test an embedded system with FPGA	Applying (K3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4
CO1	2	2		
CO2	3	3	1	1
CO3	3	3	1	1
CO4	2	2		
CO5	3	3	1	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom’s Taxonomy

18CIE14 WIRELESS EMBEDDED SYSTEMS

L	T	P	Credit
3	0	0	3

Preamble	To understand the principles and concepts of wireless embedded systems.
Prerequisites	Microprocessors and Microcontrollers, Embedded Systems

UNIT – I **9**

Introduction to Wireless Embedded Systems: Overview of embedded systems, their hardware, hardware/software interface, energy vs. power, and networking.

UNIT – II **9**

Microcontrollers Vs. Processors: MSP430, ARM A* and Cortex M*, sensors, wireless, duty cycling, flash vs. RAM, one-wire, I2C, SPI, GPIO - Threads and events, hardware considerations, programming models, state management, tasks, protothreads, fibers.

UNIT – III **9**

Energy and Power Management: Energy and power; batteries, sleep current, wakeup latency, triggers, relative power costs and lifetime breakdown, circuit design, clocks, harvesting, markets vs. fundamentals Storage; EEPROM, NOR/NAND flash, [PFM]RAM, blocks, pages, erase, abstractions, delay tolerance, indexing, Sensing; energy considerations, data rates, buffering.

UNIT – IV **9**

Introduction to Wireless Transceivers: Introduction to ZIGBEE/BTLE/LORA/WIFI/WIMAX. **LORA –** Networking, physical layer model, symbols, multipath, LQI/RSSI, channel hopping, FEC, link layer, addressing, acknowledgements, routing, queueing, reliability

UNIT – V **9**

Programming Models: Programming Models; isolation/safety, data centric, databases, scripting, frameworks. TinyOS - Programming mechanism - Application Development – Porting on Microcontroller.

Total: 45

REFERENCES:

1. Marko Hannikainen, Timo D. Hamalainen and Ville Kaseva, “Low-Power Wireless Sensor Networks: Protocols, Services and Applications”, Springer, 2012.
2. Philip Levis, David Gay, “Tiny OS Programming”, 1st Edition, Cambridge University Press, Springer, 2009.
3. Michael Barr, Anthony Massa, “Programming Embedded Systems: With C and GNU Development”, 2nd Edition, O’reilly Publishers, USA, 2006.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	aware about the different wireless nodes - different processors used for the Wireless Sensor Networks	Understanding (K2)
CO2:	interpret the different protocols for interfacing	Understanding (K2)
CO3:	experiment the different algorithms on Embedded Processors	Analyzing (K4)
CO4:	implement OS based Embedded System for Wireless applications	Analyzing (K4)
CO5:	develop Wireless Embedded test beds	Applying (K3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4
CO1	2	2		
CO2	2	2		
CO3	3	3	2	2
CO4	3	3	2	2
CO5	3	3	1	1

1 – Slight, 2 – Moderate, 3 – Substantial BT – Blooms Taxonomy

18CIE15 VIRTUAL INSTRUMENTATION FOR INDUSTRIAL APPLICATIONS

(Common to Control and Instrumentation Engineering, Embedded Systems, Applied Electronics & Power Electronics Drives branches)

L	T	P	Credit
3	0	0	3

Preamble	To impart knowledge about advanced tools in virtual instrumentation to develop new industrial applications
Prerequisites	Virtual Instrumentation

UNIT – I **9**

Graphical System Design Programming Concepts: G-Programming- debugging techniques-Loops: For loop, While Loop, Shift registers-Structures: Case Structure, Sequence Structure, Event Structure, Timed Structure-

UNIT – II **9**

Data Acquisition and Interfacing: Data Acquisition in LabVIEW-Hardware installation and configuration-DAQ components-DAQ signal Accessory-DAQ Assistant-DAQ Hardware-DAQ Software.

UNIT – III **9**

GSD Programming Toolkits: Signal Processing and Analysis-Control System Design and Simulation-Digital Filter Design-Spectral Measurements-Report generation-PID Control-Biomedical Startup kit.

UNIT – IV **9**

VI Applications Part I: Material Handling System -Fiber-Optic Component Inspection Using Integrated Vision and Motion Components-Internet-Ready Power Network Analyzer for Power Quality Measurements and Monitoring.

UNIT – V **9**

VI Applications Part II: Developing Remote Front Panel LabVIEW Applications- Using the Timed Loop to Write Multirate Applications in LabVIEW - Client–Server Applications in LabVIEW- Neural Networks for Measurement and Instrumentation in Virtual Environments.

Total: 45

REFERENCES:

1. Jovitha Jerome, "Virtual Instrumentation using LabVIEW", 3rd Edition, PHI Learning Pvt. Ltd., New Delhi, 2012.
2. Sumathi S., Surekha P., "LabVIEW based Advanced Instrumentation Systems", Springer Science & Business Media, 2007.
3. Sanjay Gupta, Joseph, John, "Virtual Instrumentation using LabVIEW", 2nd Edition, Tata McGraw Hill, 2010.

COURSE OUTCOMES: On completion of the course, the students will be able to		BT Mapped (Highest Level)
CO1:	apply structured programming concepts in developing VI programs and employ various debugging techniques	Applying (K3)
CO2:	interface hardware devices with software using DAQ system	Applying (K3)
CO3:	design, implement and analyze an application using different tools	Applying (K3)
CO4:	apply knowledge on various tools in practical works	Applying (K3)
CO5:	create virtual instruments for real time applications	Applying (K3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3	PO4
CO1	3	3	1	1
CO2	3	3	1	1
CO3	3	3	1	1
CO4	3	3	1	1
CO5	3	3	1	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy