COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY

COCHIN – 682 022

CURRICULUM AND SYLLABUS

of

M.TECH. DEGREE PROGRAMME IN INSTRUMENTATION TECHNOLOGY

offered by

Department of Instrumentation

Cochin University of Science And Technology

(With effect from 2024 Admission)

CURRICULUM FOR M.TECH. IN INSTRUMENTATION TECHNOLOGY

SEMESTER I

Sl. No.	Course code	Name of the course	Core/ Elective	Credits	Hours per week			Marks
					L	T	P	
1	24-473-0101	Soft Computing Techniques in Instrumentation	C	3	3	1	-	100
2	24-473-0102	Data Acquisition and Hardware Interfaces	C	3	3	1	-	100
3	24-473-0103	Optimal and Robust Control	C	4	4	1	-	100
4	24-473-0104	Sensor Technology Lab	C	1	-	-	3	50
5	24-473-0105	Control system and Computing Lab	C	1	-	-	3	50
6		Elective - I	E	3	3	1	-	100
7		Elective - II	E	3	3	1	-	100
Total				18				600

List of Electives

1. 24-473-0106 Advanced Digital Signal Processing
2. 24-473-0107 Process Dynamics and Control
3. 24-473-0108 Advanced Analytical Instruments
4. 24-473-0109 Optimisation Techniques
5. 24-473-0110 Robotics and Automation
6. 24-473-0111 Non Linear Control Systems
7. 24-473-0112 Advanced Biomedical Instruments
8. 24-473-0113 Adaptive Control Theory

CURRICULUM FOR M.TECH. IN INSTRUMENTATION TECHNOLOGY

SEMESTER I

Sl. No.	Course code	Name of the course	Core/ Elective	Credits	Hours per week			Marks
					L	T	P	
1	24-473-0201	Advanced Multi-sensor Data Fusion	C	3	3	1	-	100
2	24-473-0202	Wireless Sensor Networks	C	3	3	1		100
3	24-473-0203	Seminar	C	1	-	-	3	50
4	24-473-0204	Soft computing Lab	C	1	-	-	3	50
5	24-473-0205	Advanced Process control Lab	C	1	-	-	3	50
6		Elective - III	E	3	3	1	0	100
7		Elective - IV	E	3	3	1	0	100
8		Elective V	E	3	3	1	0	100
Total				18				

List of Electives

1. 24-473-0206 Digital Image Processing

2. 24-473-0207 Mechatronics

3. 24-473-0208 MEMS and Microsystems

5. 24-473-0209 Optoelectronics and Instrumentation

6. 24-473-0210 Non Destructive Testing and Analysis.

7. 24-473-0211 Navigation Guidance and Control

8. 24-473-0212 Embedded System Design

9. 24-473-0213 Remote Sensing and Geographical Information Systems

10. 24-473-0214 Internet of Things.

11. 24-473- 0215 Fractional Order System and Control

CURRICULUM FOR M.TECH. IN INSTRUMENTATION TECHNOLOGY

SEMESTER III

Sl. No.	Course code	Name of the course	Core/Elective	Credits	Marks
1	24-473-0301	Open Elective- I*	E	3	100
2	24-473-0302	Project Progress Evaluation	C	15	400
Total				18	500

CURRICULUM FOR M.TECH. IN INSTRUMENTATION TECHNOLOGY

SEMESTER IV

Sl. No.	Course code	Name of the course	Core/Elective	Credits	Marks
1	24-473-0401	Open Elective - II*	E	3	100
2	24-473-0402	Project Dissertation Evaluation	C	15	400
Total				18	500

* The students shall select these courses from the list of courses available from approved national agencies such as SWAYAM, subject to the approval of the department council. The students are responsible to pay the course fee, if any, attend these online courses, pass the exam and produce the certificate. The percentage of marks/credit will be given according to the marks obtained in the above examination.

Total credits for the course = 18+18+18+18 = 72

Program Outcomes (POs)

POs are statements that describe what students are expected to know and be able to do upon graduating from the program. These relate to the skills, knowledge, analytical ability, attitude and behaviour that students acquire through the program.

The POs essentially indicate what the students can do from subject-wise knowledge acquired by them during the program. As such, POs define the professional profile of a graduate of PG Engineering Program.

NBA has defined the following three POs for a graduate of PG Engineering Program:

i) PO1: An ability to independently carry out research /investigation and development work to solve practical problems.

ii) PO2: An ability to write and present a substantial technical report/document.

iii) PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

24-473-0101 SOFT COMPUTING TECHNIQUES IN INSTRUMENTATION

L	T	P	C
3	1	0	3

Pre-requisites: Nil

Total Hours: 64

Course Objectives:

To provide the student with the basic understanding of neural networks and fuzzy logic fundamentals, Program the related algorithms and design the required and related systems.

To understand the fundamental theory and concepts of neural networks, several neural network paradigms and its applications.

To understand the basics of an evolutionary computing paradigm known as genetic algorithms and its application to engineering optimization problems

Course Outcomes

After the completion of the course, the student will be able to –

CO 1. Define basic concepts of neural networks and fuzzy systems.

CO 2. Develop and train different supervised and unsupervised learning.

CO 3. Classify various nature inspired algorithms according to their application aspect.

CO 4. Analyze and compare the efficiency of various hybrid systems.

CO 5. Design a soft computing model for solving real world problems.

CO-PO Mapping

PO	**CO 1**	**CO 2**	**CO 3**	**CO 4**	**CO 5**
PO 1	2	1	3	2	3
PO 2	2	2	2	1	3
PO 3	3	3	3	3	3

MODULE I

Introduction to Soft Computing: Soft Computing v/s Hard Computing, Human brain and the biological neuron, Artificial Neurons, Neural Networks and architectures, feed forward and feedback architectures, Terminologies of ANNs McCulloch-Pitts Neurons, Linear Separability, Learning Rules, Hebb Network, Supervised Learning Networks: Introduction, Perceptron Networks, LMS, Back Propagation Networks, Fast variants of Back propagation.

MODULE II

Support vector machines, RBFNNs, learning in RBFNNs, Image classification application, PNNs, Associative learning, associative memory, Hopfield memory, Simulated annealing and the Boltzmann Machine, BAM, ART principles, Self-Organizing Maps.

Statistical pattern recognition perspective of ANNs: Bayes theorem, implementing classification decisions with the Bayes theorem, interpreting neuron signals as probabilities,

MODULE III

Fuzzy Sets, Fuzzy Membership Functions, Operations on Fuzzy Sets, Fuzzy Relations, Fuzzy rules, Fuzzy Reasoning, Defuzzification: Lambda-Cuts for Fuzzy sets (Alpha Cuts), Lambda-Cuts for Fuzzy Relations. Fuzzy Inference System: Introduction, Mamdani Fuzzy Model, Takagi-Sugeno Fuzzy Model.

Neural Networks and Fuzzy logic, Fuzzy neurons, Fuzzy perceptron, Fuzzy classification networks using Backpropagation, Fuzzy ART, Adaptive Neuro fuzzy inference system (ANFIS)

MODULE IV

Evolutionary Algorithm, Traditional optimization and Search Techniques, Basic Terminologies in GA, Operators in Genetic Algorithm, Stopping Condition for Genetic Algorithm Flow, Classification of Genetic Algorithm, Comparison with Evolutionary algorithm, Application of Genetic algorithm.

Swarm Intelligent Systems: Ant Colony Systems (ACO): Biological concept, artificial systems, Applications, Particle Swarm Intelligent Systems – PCO method, Applications.

MODULE V

Differential Evolution (DE) Algorithm, Artificial Bee Colony (ABC) Algorithm, Cuckoo Search (CS), Firefly Algorithm (FA), Immune Algorithm (IA), Grey Wolf Optimization (GWO), Spider Monkey Optimization.

Application of Soft Computing Techniques, Image Fusion, Traveling SalesMan Problem, Flexible Robots, GA Based internet search techniques.

REFERENCES

1. Principles of Soft Computing, S. N. Sivanandam and S. N. Deepa , Wiley Neural Networks (2018)
2. Fuzzy Logic and Genetic Algorithms: Synthesis and Applications- S. Rajasekaran &G.A. Vijayalakshmi Pai, PHI. (2017)
3. Introduction to Soft Computing Neuro-Fuzzy and Genetic Algorithms, Samir Roy and Udit Chakraborty, Pearson. (2013)
4. Neural Networks and Learning Machines-Simon Haykin PHI. (2022)
5. Fuzzy Logic and Engineering Application, Tomthy Ross, TMH. (2011)
6. Evolutionary Optimization Algorithms, D. Simon Wiley. (2013),
7. Fundamentals of Natural Computing: Basic Concepts, Algorithms, and Applications, L.N. de Castro, CRC Press. (2012)

8. Nature-inspired Computing Design, Development, and Applications, Leandro Nunes De Castro Medical Information Science Reference (2012)

9. Neural Networks, A Class room approach, Satish Kumar, Tata McGraw Hill, (2017)

10. Artificial Intelligence and Intelligent Systems, N.P Padhy, Oxford University Press, (2005).

24-473-0102 DATA ACQUISITION AND HARDWARE INTERFACES

L	T	P	C
3	1	0	3

Pre-requisites: Nil
Total Hours: 64
Course Outcomes: After completion of this course, the student will be able to

CO1:	Understand the basics of various bus topology and computer interfacing.
CO2:	Comprehensively analyze signal conditioning, signal conversion, data acquisition, and signal processing.
CO3:	Utilize A/D and D/A converter in various applications.
CO4:	Acquainted with various data acquisition methods and Interface Standards and PC buses.
CO5:	Integrate and program various distributed and stand-alone Loggers.

Mapping of course outcomes with program outcomes

	CO 1	CO 2	CO 3	CO4	CO5
PO1	2	1	-	2	3
PO2	1	2	-	1	1
PO3	3	3	-	3	2

Module 1
Fundamentals of Data Acquisition: Transducers and sensors - Field wiring and communications cabling - Signal conditioning - Data acquisition hardware - Data acquisition software - Host computer - Essentials of computer interfacing –Configuration and structure – interface systems - Interface bus.
Data acquisition and control system configuration: Computer plug-in I/O - Distributed I/O - Stand-alone or distributed loggers/controllers - IEEE 488 (GPIB) remote programmable instruments.
Design of Signal Conditioning Circuit: Signal amplifiers, Analog filters, Digital and pulse train conditioning, Two-wire transmitter, and Distributed I/O - High-speed digital transmitter, Noise reduction and isolation.

Module 2
Plug-in data acquisition boards:
A/D boards: Multiplexers, Input signal amplifier, Channel-gain arrays, Sample and hold circuits, A/D converters, Memory (FIFO) buffer, Timing circuitry, and Expansion bus interface.
Single vs. Differential signals - Resolution, dynamic range, and accuracy of A/D boards - Sampling techniques - Speed vs throughput.
D/A boards: Digital to analog converters, Parameters of D/A converters, Functional characteristics of D/A boards, Memory (FIFO) buffer, Timing circuitry, Output amplifier buffer, and Expansion bus interface.
Digital I/O boards - Interfacing digital inputs/outputs - Counter/timer I/O boards.

Module 3

Interface Standards and PC Buses: Transmission modes – simplex and duplex - RS-232-C interface standard: Electrical signal characteristics, Interface mechanical characteristics, Functional description of the interchange circuits, The sequence of operation of the EIA-232 interface, Examples of RS-232 interfaces, and Main features of the RS-232 Interface Standard. RS422 - RS485 - 20 mA current loop – Comparison between RS-232, RS422, and RS485 - GPIB. USB: USB overall structure, the physical layer, the data link layer, and the application layer. Firewire; Backplane buses - PCI, PCI-Express, PXI, PXI – Express, VME, VXI; Ethernet – TCP/IP protocols.

Module 4

Distributed and Stand-alone Loggers: Introduction **-** Methods of operation: Programming and logging data using PCMCIA cards, stand-alone operation, direct and remote connection to host PC – power management circuitry. - Stand-alone logger/controller hardware - Communications hardware interface - Stand-alone logger/controller firmware - Stand-alone logger/controller software design - Host software - Stand-alone logger/controllers vs internal systems.

IEEE 488 Standard: Introduction - Electrical and mechanical characteristics - Physical connection configurations - Device types - Bus structure - GPIB handshaking - Device communication - IEEE 488.2 - Standard commands for programmable instruments (SCPI).

Module 5

Ethernet and LAN Systems: Ethernet and field buses for data acquisition - Physical layer - Medium access control - MAC frame format - Difference between 802.3 and Ethernet - Reducing collisions - Ethernet design rules - Fieldbuses.

Virtual Instrumentation: Virtual instrument and traditional instrument - Hardware and software for virtual instrumentation - Virtual instrumentation for test, control, and design - Graphical system design - Graphical, and textual programming - DAQ hardware configuration - DAQ hardware - Analog I/O, Counters, Digital I/O - DAQ Software Architecture - DAQ assistant - Selecting and configuring a data acquisition device - components of a computer-based measurement system.

References:

1. Ramon Pallas-Areny and John G Webster, Sensors and Signal Conditioning, 2012, 2nd ed., Wiley India Pvt. Ltd.
2. John Park and Steve Mackay, Practical Data Acquisition for Instrumentation and Control, 2011, 1st ed., Newness publishers, Oxford, UK.
3. Maurizio Di Paolo Emilio, Data Acquisition systems- from Fundamentals to Applied Design, 2013, 1st ed., Springer, New York.
4. Robert H King, Introduction to Data Acquisition with LabVIEW, 2012, 2nd ed., McGraw Hill, New York.
5. Jerome, PHI Virtual Instrumentation using LabVIEW, Jovitha, ISBN 978-81-203-40305, 2010.
6. Gary Johnson - Labview Graphical Programming, Second edition, McGraw Hill. 1997.

24-473-0103 OPTIMAL AND ROBUST CONTROL

L	T	P	C
4	1	0	4

Pre-requisites: Nil

Total Hours: 64

Course Outcomes:

After completion of this course, the student will be able to

CO1:	Apply the various concepts in the mathematical area of 'calculus of variation' for solving optimal control problems.
CO2:	Develop methods of problem formulation pertaining to optimal control and design of optimal controllers
CO3:	Analyze robustness of systems and develop skills useful in controlling systems when accurate mathematical models are unavailable
CO4:	Design and synthesis robust controllers for practical systems

Mapping of course outcomes with program outcomes

	CO1	**CO2**	**CO3**	**CO4**
PO 1	3	3	3	3
PO 2	1	1	1	1
PO 3	3	3	3	3

MODULE 1:

Calculus of variations: Examples of variational problems, Basic calculus of variations problem, Weak and strong extrema, Variable end point problems, Hamiltonian formalism and mechanics: Hamilton's canonical equations.

From Calculus of variations to Optimal control :Necessary conditions for strong extrema, Calculus of variations versus optimal control, optimal control problem formulation and assumptions, Variational approach to the fixed time, free end point problem. The Pontryagin's Minimum principle: Statement of Minimum principle for basic fixed endpoint and variable end point control problems, Proof of the minimum principle, Properties of the Hamiltonian, Time optimal control problems. Minimum energy problems.

MODULE 2:

Linear Quadratic Regulator: Finite horizon LQR problem-Candidate optimal feedback law, Ricatti differential equations (RDE), Global existence of solution for the RDE. Infinite horizon LQR problem-Existence and properties of the limit, solution, closed loop stability.LQR using output feedback: Output feedback LQR design equations, Closed loop stability, Solution of design equations. Numerical solution of Riccatti Equations-Linear Quadratic tracking control: Tracking a reference input with compensators of known structure, Tracking by regulator redesign, Command generator tracker, Explicit model following design. Linear Quadratic Guassian controller (LQG) and Kalman-Bucy Filter: LQG control equations, estimator in feedback loop, steady state filter gain, constraints and minimizing control, state estimation using Kalman-Bucy Filter, constraints and optimal control.

MODULE 3:

Robust Control - Control system representations, System stabilities, Co-prime factorization and stabilizing controllers, Signals and system norms, Modeling of uncertain systems - Unstructured Uncertainties-Additive, multiplicative and other forms. Parametric uncertainty, Interval Systems, Structured uncertainties

MODULE 4:

Linear fractional transformation Robust design specifications: Small gain theorem and robust stabilization, Performance considerations, Structured singular values. Design - Mixed sensitivity optimization, 2-Degree of freedom design, Sub-optimal solutions, H2 /H∞ Systems.

MODULE 5:

Loop-shaping design procedures: Robust stabilization against Normalized co-prime factor perturbation, Loop shaping design procedures, μ - Analysis and Synthesis - Consideration of robust performance, μ-synthesis: D – K iteration method, Schur Compliment & Linear Matrix Inequalities: Some standard LMI problems – eigen - value problems, generalized eigen - value problems; Algorithms to solve LMI problems – Ellipsoid algorithm, interior point methods

REFERENCES:

1. D. W.Gu, P. Hr.Petkov and M.M.Konstantinov, ‘Robust Control design with MATLAB’, Springer, 2005.
2. Alok Sinha, ‘Linear Systems-Optimal and Robust Controls’, CRC Press, 2007.
3. S. Skogestad and Ian Postlethwaite, ‘Multivariable feedback control’, John Wiley & Sons, Ltd, 2005.
4. G.E. Dullerud, F. Paganini, ‘A course in Robust control theory-A convex approach’, Springer, 2000.
5. Kemin Zhou with J.C. Doyle and K. Glover, ‘Robust and Optimal Control,’ Prentice Hall, 1996.
6. Kemin Zhou, John Comstock Doyle, Keith Glover, ‘Robust and optimal control,’ PrenticeHall,1996.
7. Kemin Zhou, John Comstock Doyle, Essentials of robust control, Prentice Hall, 1998.
8. Stephen Boyd, Laurent El Ghaoul, Eric Feron, ‘Linear Matrix Inequalities in System and ControlTheory’, SIAM, 1994.

24-473-0104 SENSOR TECHNOLOGY LAB

L	T	P	C
0	0	3	1

Pre-requisites: Nil

Total Hours: 64

Course Outcomes:

After completion of this course, the student will be able to

CO1:	Obtain response characteristics of various sensors and transducers.
CO2:	Evaluate the performance of various sensors.
CO3:	Design and implement programs in LabView.
CO4:	Acquire sensor data with LabView software using different interfacing hardware.

Mapping of course outcomes with program outcomes

	CO1	**CO2**	**CO3**	**CO4**
PO1	2	1	-	2
PO2	1	2	-	1
PO3	3	3	-	3

List of Experiments:

1. Familiarization of LabVIEW.
2. Creating Virtual Instrumentation for simple applications.
3. Programming exercises for loops, clusters, charts and graphs.
4. Programming exercises on arrays and clusters.
5. Programming exercises on SubVI.
6. Programming exercises on case and sequence structures, file Input / Output.
7. Developing voltmeter using DAQ cards.
8. Developing signal generators using DAQ cards.
9. Response characteristics of thermistor.
10. Current measurement using Hall effect transducer.
11. Controller using optical transducer (LDR).
12. Response characteristics and coefficients of RTD.
13. Phase detection electronics circuit for capacitive transducer with 7556 dual timer.
14. Active bridge circuit, active low and high pass filter.

Also, it is expected that the students must learn to use the latest equipment and software so that the industry gets trained engineers.

24-473-0105 CONTROL SYSTEM AND COMPUTING LAB

L	T	P	C
0	0	3	1

Pre-requisites: Nil

Total Hours: 64

Course Outcomes:

After completion of this course, the student will be able to

CO1:	Use the software MATLAB and MATLAB Control System Toolbox.
CO2:	Represent physical systems as transfer functions and derive open loop and closed loop transfer functions.
CO3:	Compare first order and second order systems and its performance.
CO4:	Design control components like PID controller, compensator etc.

Mapping of course outcomes with program outcomes

	CO1	CO2	CO3	CO4
PO1	3	3	1	2
PO2	2	2	1	2
PO3	2	3	2	3

List of experiments: (8 -10 experiments to be done)

1. Familiarization with MATLAB and MATLAB Control System Toolbox.
2. Transfer functions
3. Time domain analysis and steady state errors
4. Proportional Integral Derivative Control
5. Stability analysis using Bode plots and Nyquist plots
6. State Space analysis - Controllability, Observability and system gain
7. Pole placement and Root locus
8. Compensation design using Lag, Lead compensators
9. Compensators using Lead – Lag approaches
10. Models of Practical systems like electric Power System
11. Familiarization of digital Control System Analysis
12. Analysis of stability in the digital domain.

Text Book

1. D. Frederick and J. Chow, Feedback control problems using MATLAB, Brooks/Cole Thomson Learning, 2000

References

1. MATLAB documentation.
2. Control System ToolBox documentation
3. Ogata Modern Control Engineering, Tata McGraw Hill, 1998

FIRST SEMESTER ELECTIVES

21-473-0112 ADVANCED BIOMEDICAL INSTRUMENTS

L	T	P	C
3	1	0	3

Pre-requisites: Nil
Total Hours: 64

Course Outcome:
On completion of the course the student will be able to:

- **CO1:** Explain the sources of bioelectric potentials and theory behind biopotential electrodes.
- **CO2:** Describe various medical devices, imaging technologies, and diagnostic techniques used in modern biomedical applications.
- **CO3:** Explain fundamental principles, technology, operation modes, and applications of ultrasonic imaging systems in medical diagnosis and therapy.
- **CO4:** Identify lasers in various medical procedures, including surgery and diagnostics, as well as the advantages and applications of laser technology in healthcare.
- **CO5:** Employ instrumentation in medical thermography, quantitative analysis techniques, as well as computer applications in medicine, including ECG analysis, catheterization laboratories, and patient monitoring systems.

Mapping of course outcomes with program outcomes

	PO 1	**PO 2**	**PO 3**
CO1	1	-	3
CO2	-	-	3
CO3	2	2	3
CO4	2	2	3
CO5	1	-	3

MODULE 1

Development of Biomedical Instrumentation, biometrics, Man-instrument system-components-block diagram, Problems encountered in biomedical measurements. Sources of bioelectric potentials - resting and action potentials -propagation of action potentials bioelectric potentials - examples (ECG, EEG, EMG, ERG, EOG, EGG, etc.) Biopotential electrodes– theory-microelectrodes- skin surface electrodes- needle electrodes - transducers for biomedical applications.

MODULE 2

Heart-Iung machine -Artificial heart valves -Pacemakers and Defibrillators - Anaesthesia machine. Blood cell counter -digital thermometer -Audiometer - Electron Microscope - Ventilator biomaterials.

X- ray machine -Radiography, fluoroscopy -image intensifiers -Conventional X-ray Imaging - Angiography -Computed tomography -linear tomography -tomography scanner- applications. Magnetic Resonance Imaging systems -Basic NMR components.

MODULE 3

Ultrasonic imaging systems -Physics of ultrasonic waves, medical ultrasound. construction of an ultrasonic transducer. different modes of operations of ultrasound -A scan, B scan -Echocardiography (M mode), Real time ultrasonic imaging system, Computer controlled ultrasonic imaging - Applications.

MODULE 4

Laser application in machine -Laser- Pulsed Ruby Laser, Nd- AG laser, Argon Laser, CO_2 laser, Helium-neon laser -applications -Advantages of laser surgery -Laser based Doppler blood flow meter- Endoscope -Cardio scope -Laproscope -Endoscopic laser coagulator cryogenic surgery.

MODULE 5

Medical thermography -Physics of theromography -Themographic equipment - Quantitative medical thermography -Infrared and Microwave Thermography- Medical applications of thermography. Computer applications in Medicine - Computer aided ECG analysis-Computerized Catheterisation Laboratory -Computerised patient monitoring system.

Text Books

1. Leslie Cromwel -Biomedical instrumentation and measurements -Prentice Hall.
2. L.A. Geddes and L.E. Baker -Principles of Applied biomedical instrumentation -John Wiley and sons.

References

1. B. Jacobson and J.G. Webster -Medicine and Clinical Engineering -Prentice Hall of. India
2. Macka Sturat Biomedical telemetering- John Wiley.
3. R.S. Khandpur -Handbook of biomedical engineering -Tata McGraw Hill.

24-473-0113 ADAPTIVE CONTROL THEORY

L	T	P	C
3	1	0	3

Pre-requisites: Nil

Total Hours: 64

Course Outcomes:

After completion of this course, the student will be able to

CO1:	Integrate the concepts of norms and spaces to be applied in adaptive control theory
CO2:	Apply identification techniques for design of adaptive controller
CO3:	Explain direct and indirect adaptive control techniques
CO4:	Describe advanced adaptive control methods along with case studies and computer simulations

Mapping of course outcomes with program outcomes

	CO1	CO2	CO3	CO4
PO 1	3	3	-	-
PO 2	-	-	-	3
PO 3	3	3	2	3

Module 1: Preliminaries

Norms and Lp spaces-positive definite matrices-input –output stability-Lp stability-small gain theorem-Positive real functions and stability-Analysis of Dynamical Systems, Analysis of Solutions to Differential Equations, Equilibria and Stability. Invariant Sets. Lyapunov Stability Theory and Performance Analysis., Nonautonomous Systems., LaSalle Extensions, Barbalat Lemma.

Module 2: Adaptive Control Basics

Basic approaches to adaptive control -Applications of adaptive control. Introduction to types of Adaptive Control-Model Reference-Variable Structure-Sliding Mode- Neuro-Fuzzy-Learning Control-Intelligent Control using schematic diagrams and literature survey.

Module 3: Identification

Identification problem- Identification of linear time-invariant systems. Adaptive observers. Sufficient richness condition for parameter convergence. Equation error and output error methods. Gradient and least squares algorithms: Linear error equation. Gradient and normalized gradient algorithms. Least-squares algorithms (batch, recursive, recursive with forgetting factor). Convergence properties. Identification for Control.

Frequency-domain analysis and averaging approximations: Averaging of signals. Averaging theory for one-time scale and two-time scale systems. Applications to adaptive systems.

Module 4: Model Reference Adaptive Control

Indirect adaptive control: Pole placement adaptive control. Model reference adaptive control. Predictive control. Singularity regions and methods to avoid them. Direct adaptive control: Filtered linear error equation. Gradient and pseudo-gradient algorithms. Strictly positive real transfer functions and Kalman-Yacubovitch-Popov lemma. Lyapunov redesign. Passivity theory. Direct model reference adaptive control. One case study of MRAC and computer based design.

Module 5: Methods in Adaptive Control

Adaptive Backstepping, Adaptive Output Feedback Control, Adaptive Neuro Control, Examples of Adaptive Control. One case study and computer simulation.

References:

1. K.J. Astrom and B. Wittenmark, 'Adaptive Control', Addison-Wesley, 2nd edition, 1995.
2. P.A. Ioannou& J. Sun, 'Robust Adaptive Control', Prentice Hall, Upper Saddle River, NJ, 1996.
3. I.D. Landau, R. Lozano, and M. M'Saad, 'Adaptive Control', Springer Verlag, London, 1998.
4. K.S. Narendra and A.M. Annaswamy, 'Stable Adaptive Systems', Prentice-Hall, 1989.
5. S. Sastry and M. Bodson, 'Adaptive Control: Stability, Convergence, and Robustness', Prentice-Hall,1989.
6. https://onlinecourses.nptel.ac.in/noc22_me129/preview

24-473-0201 ADVANCED MULTISENSOR DATA FUSION

L	T	P	C
3	1	0	3

Pre-requisites: Nil

Total Hours: 64

Course Outcomes:

At the end of this course, students will demonstrate the ability to:

CO1: Understand the fundamental principles of sensor data fusion, including the concept of multiple sensors, fusion applications, and the inference hierarchy.
CO2: Analyze and implement algorithms for multi-sensor data fusion, including data association, feature extraction, and identity declaration.
CO3: Gain knowledge and skills in estimation methods such as Kalman filtering, decision-level identity fusion, and Bayesian inference for effective data fusion.
CO4: Acquire expertise in pixel and feature-level image fusion techniques, including image registration, segmentation, target tracking, and performance evaluation metrics.
CO5: Demonstrate the ability to implement and optimize data fusion systems, including decentralized estimation, sensor fusion algorithms, and high-performance data structures, to meet specified dependability and scalability requirements.

CO-PO Mapping

PO	**CO 1**	**CO 2**	**CO 3**	**CO 4**	**CO 5**
PO 1	2	3	2	3	3
PO 2	2	1	2	2	3
PO 3	3	3	3	3	3

MODULE 1

Introduction, Sensors and sensor data, Use of multiple sensors, Fusion applications. The inference hierarchy: output data. Data fusion model. Architectural concepts and issues. Benefits of data fusion, Mathematical tools used: Algorithms, co-ordinate transformations, rigid body motion. Dependability and Markov chains, Meta – heuristics.

MODULE 2

Algorithms for Data Fusion, Taxonomy of algorithms for multi-sensor data fusion. Data association. Identity declaration. Concept of Data Association/ Correlation Problem, Process Model for Correlation, Hypothesis Generation, Hypothesis Evaluation, Hypothesis Selection Techniques

Feature Extraction - examples of image features and signal data features for identity declaration, features available from different sources, Parametric templates, Cluster analysis techniques,, Physical models for identity declaration, Knowledge- based methods and Hybrid techniques for identity declaration, Identity Declaration and Pattern Recognition.

MODULE 3

Estimation, Kalman filtering, practical aspects of Kalman filtering, extended Kalman filters. Decision level identify fusion. Knowledge based approaches. Classical inference, Bayesian inference,

Heuristic methods for identity fusion, Implementation and trade-offs involved in the utilization of different techniques to perform identity fusion

MODULE 4

Pixel and Feature-Level Image Fusion, Concepts and Algorithms. Image Registration. Area-Based Matching. Feature-Based Methods. Transform Model. Resampling and Transformation, Segmentation, Centroid Detection, and Target Tracking with Image Data, Image Noise, Metrics for Performance Evaluation. Pixel-Level Fusion Algorithms. Principal Component Analysis Method, Spatial Frequency, Performance Evaluation, Wavelet Transform, Feature-Level Fusion Methods, Fusion of Appearance and Depth Information, Stereo Face Recognition System, Feature-Level Fusion, Match Score Generation, Illustrative Examples.

MODULE 5

Data information filter, extended information filter. Decentralized and scalable decentralized estimation. Sensor fusion and approximate agreement. Optimal sensor fusion using range trees recursively. Distributed dynamic sensor fusion.

High Performance Data Structures- Tessellated, trees, graphs and function. Representing ranges and uncertainty in data structures. Designing optimal sensor systems within dependability bounds. Implementing a data fusion system.

REFERENCES

1. David L. Hall, Mathematical techniques in Multi-sensor data fusion, Artech House, Boston. (2004)
2. Jitendra R Raol, Data Fusion Mathematics: Theory and Practice, CRC Press, (2016).
3. Liping Yan, Lu Jiang, Yuanqing Xia, Multisensor Fusion Estimation Theory and Application, Springer Nature Singapore (2020)
4. Arthur Gelb, Applied Optimal Estimation, M.I.T. Press. (1998)
5. James V. Candy, Signal Processing: The Model Based Approach, McGraw –Hill Book Company (1986)
6. David L. Hall, Sonya A.H. McMullen, Mathematical Techniques in Multisensor Data Fusion, Second Edition, Artech House, Boston, (2004).
7. R. Brooks and S.S. Iyengar, Multisensor Fusion: Fundamentals and Applications with Software, Prentice Hall Inc., New Jersey, (1998).

8. Thor I. Fossen, Kristin Y. Pettersen, Henk Nijmeijer: Sensing and Control for Autonomous Vehicles: Applications to Land, Water and Air Vehicles, Springer, The Netherlands, (2017).
9. Tom Denton : Automated Driving And Driver Assistance Systems, IMI, NY, (2020).

24-473-0202 WIRELESS SENSOR NETWORKS

L	T	P	C
3	1	0	3

Pre-requisites: Nil

Total Hours: 64

Course Outcomes:

After completion of this course, the student will be able to

CO1:	Explain the Fundamental Concepts and applications of wireless sensor networks.
CO2:	Explain the architectures, functions, and performance of wireless sensor network systems and platforms.
CO3:	Explain various network-level protocols for MAC, routing, time synchronization, aggregation, consensus, and distributed tracking and design issues.
CO4:	Explain the various levels of information processing in wireless sensor networks.
CO5:	Explain the hardware and software platforms used in the design of WSN.

Mapping of course outcomes with program outcomes

	CO1	CO2	CO3	CO4	CO5
PO1	3	3	3	3	3
PO2	3	3	3	3	3
PO3	3	3	3	3	3

Module 1

Introduction: Introduction and overview of Wireless Sensor Networks (WSN), Commercial and Scientific Applications of WSN, Category of Applications of WSN, Challenges for WSN, Enabling Technologies for WSN.

Module 2

WSN Architecture: Single node Architecture: Hardware Components, Energy Consumption of Sensor nodes, Operating Systems and Execution Environments, Examples of Sensor Nodes, Network Architecture: WSN Scenarios, Optimization Goals and figures of Merits, Design principles for WSNs, Service Interfaces for WSNs, and Gateway Concepts.

Module 3

WSN Protocols: Physical Layer: Wireless Channel and Communication Fundamentals,

Physical Layer & Transceiver Design Considerations in WSN, MAC Protocols: Fundamentals, MAC Protocols for WSNs, IEEE802.15.4 MAC Protocol, Routing Protocols: Gossip and agent based unicast protocols, Energy Efficient Unicast, Broadcast and Multicast, Geographic Routing, Transport Control Protocols: Traditional Protocols, Design Issues, Examples of Transport Protocols.

Module 4

Information Processing: Sensor Tasking and Control: Information-Based Sensor Tasking, Joint Routing Information Aggregation, Sensor Network Databases: Challenges, Query Interfaces, In-Network Aggregation, Data Centric Storage, Data Indices and Range queries, Distributed Hierarchical Aggregation, Temporal Data.

Module 5

Applications and Design of WSN: Target detection and tracking, Habitat monitoring, Environmental disaster monitoring, Practical implementation issues, IEEE 802.15.4 low rate WPAN, Sensor Network Platforms and tools-Sensor node hardware, Node-level software platforms, node –level simulators.

References:

1.	Kazem Sohraby, Daniel Minoli, Taieb Znati, "Wireless Sensor Networks: Technology, Protocols, and Applications", John wiley & Sons.
2.	Holger Karl, Andreas Willig, "Protocols and architectures for wireless sensor networks", John wiley & Sons.
3.	Feng Zhao and Leonidas J. Guibas, "Wireless Sensor Networks: An Information Processing Approach", Elsevier, 2004.
4.	Holger Karl and Andreas Willig, "Protocols and Architectures for Wireless Sensor Networks", John Wiley, 2007.
5.	Ivan Stojmenovic, "Handbook of Sensor Networks: Algorithms and Architectures", Wiley, 2005.
6.	Kazem Sohraby, Daniel Minoli and Taieb Znati, "Wireless Sensor Networks: Technology, Protocols and Applications", John Wiley, 2007.
7.	Bhaskar Krishnamachari, "Networking Wireless Sensors", Cambridge University Press, 2011.

24-473-0203 SEMINAR

L	T	P	C
0	0	3	1

Pre-requisites: Nil

Total Hours: 64

Course Outcomes:

After completion of this course, the student will be able to

CO1:	Carry out a literature survey on new research areas.
CO2:	Organize and illustrate technical documentation with sufficient literal standards.
CO3:	Abide by professional ethics while reporting findings and stating claims.
CO4:	Demonstrate communication skills through the oral presentation using modern presentation tools.

Mapping of course outcomes with program outcomes

	CO1	**CO2**	**CO3**	**CO4**
PO1	2	1	-	2
PO2	1	2	-	1
PO3	3	3	-	3

All the students of II semester will be required to deliver a seminar, on the topic relevant to recent trends in "Control and Instrumentation Systems" using power point presentation.Topics are selected in consultation with their supervisors. Presentation will be of 20 minutes duration followed by a question answer session before a duly constituted evaluation committee of Faculty Members of the department. A report of the seminar in the form of hard copy must also be submitted in the office after approval by the committee.

24-473-0204 SOFT COMPUTING LAB

Course Outcomes:

At the end of this course, students will demonstrate the ability to:

CO1: Illustrate soft computing techniques like neural networks and fuzzy logic and their roles in building intelligent systems.

CO2: Illustrate and implement the various learning rules

CO3: Comprehend the fuzzy logic and the concept of fuzziness involved in various systems and fuzzy set theory.

CO4: Understand the concepts of fuzzy sets, knowledge representation using fuzzy rules, approximate reasoning, fuzzy inference systems, and fuzzy logic

CO5: Design and Implement real-life examples using fuzzy logic and genetic algorithms

CO – PO Mapping

PO	**CO 1**	**CO 2**	**CO 3**	**CO 4**	**CO 5**
PO 1	1	1	1	2	3
PO 2	2	2	2	3	2
PO 3	3	3	3	3	3

List of Experiments:

The following experiments are to be demonstrated using any of the software tools like MATLAB, Python etc.

1. Write a program to implement the Perceptron Training Algorithm.
2. Write a program to Implement Hebb's Rule
3. Write a program to Implement Delta Rule
4. Write a program to implement the Back-propagation algorithm
5. Write a program to implement a Hopfield Net
6. Write a program to implement a BAM
7. Write a program to Implement PCA
8. Write a program to Implement SVM
9. Write a program for pattern classification/pattern recognition
10. Write a program to study Fuzzy vs. crisp Logic.
11. Write a program to study and implement fuzzy set operations.

12. Write a program to illustrate the various fuzzy operations
13. Write a program to study and implement fuzzy relational operations.
14. Write a program to design and implement a fuzzy temperature controller.
15. Write a program to design and implement a Fuzzy Traffic light controller.
16. Write a program to study and implement the concept of Fuzzy C – means Clustering.
17. Write a program to implement Genetic Algorithms
18. Write a program to solve TSP (Travelling Salesman Problem) using a genetic algorithm.

24-473-0205 ADVANCED PROCESS CONTROL LAB

L	T	P	C
0	0	3	1

Pre-requisites: Nil

Total Hours: 64

Course Outcomes:

After completion of this course, the student will be able to

CO1: Design and simulate PID controller for various processes.
CO2: Acquire and process data using different data acquisition systems
CO3: Tune the controllers with different methods
CO4: Analyse and implement various advanced control loops
CO5: Analyse the stability of process control systems.
CO6: Implement signal conditioning circuits.

Mapping of course outcomes with program outcomes

	CO1	**CO2**	**CO3**	**CO4**	**CO5**	**CO6**
PO1	3	3	3	3	3	2
PO2	3	2	2	3	3	1
PO3	-	-	-	-	-	-

8 -10 Experiments from Both Cycles (4-5 from each)

Cycle - I

1. Design and simulation of PID controller for Temperature process station.

2. To acquire and display a continuously changing physical variable in the system using Lab View/Matlab/ Custom software.

3. Program to implement online data processing and data logging.

4. Experimentation of a Multi process Trainer.

5. To implement discrete control strategy using both analog and digital Siemens PLC.

6. To study on the interface of PLC with PC for data acquisition applications.

7. To develop stand alone executable signal conditioning files as library files in LabView/Matlab.

8. Experimentation of Control loops for Inverted Pendulum.

9. Implementation of Digital PID Controller.

10. Signal Conditioning Circuit for Temperature Measurement.

11. System Identification by the Method of Approximation.

12. Controller tuning by Frequency domain analysis.

Cycle - II:

1. To analyse the stability of a level control system with time delay in frequency domain analysis.

2. To auto tune a PID controller using a relay switch method for process control systems

3. To study the phenomenon of the reset windup and to compensate it with anti reset Windup technique for a first order process.

4. To analyse the stability of the discrete control system and to compare it with the continuous control system using IMC.

5. To study the robustness of the simple first order time delay process with frequency response analysis.

6. Design and simulation of split range controller.

7. Computer calibration of temperature and pressure measuring instruments

8. Design and simulation of cascade controller.

9. Experimental Study of DCS and SCADA in a process control system.

10. To study the action of ON/OFF, P, PI, PID control for pressure process station.

11. Stability analysis of process control systems.

12. Study of performance and automation of a flexible manufacturing trainer.

Text Books

1. Curtis D. Johnson –Microprocessors in Process Control, PHI. 1993 Reference

2. George Stephanooulos Chemical Process Control. 2005

3. Coughner Process Analysis & Control, Tata Mcgraw Hill. – 1991

SECOND SEMESTER ELECTIVES

21-473-0209 OPTOELECTRONICS AND INSTRUMENTATION

L	T	P	C
3	1	0	3

Pre-requisites: Nil
Total Hours: 64

Course Outcome:
After the completion of the course the student will be able to

CO1: Describe the principle and operation of interferometers, and various modulation techniques used in optical systems.
CO2: Outline the basic theory of lasers, including their principles of operation, and their properties.
CO3: Explain the operation of different classes of lasers, their operation principles, and their wide-ranging applications in various fields including industrial, biomedical, and environmental sciences.
CO4: Give an account of fibre optics and various fibre optic components, measurement techniques, and associated equipment such as OTDRs, couplers, splicers, and connectors.
CO5: Illustrate various sensor applications of optical fibers, including their principles, applications, and associated technologies such as fiber Bragg gratings and photonic band gap materials.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3
CO1	2	2	3
CO2	2	-	3
CO3	3	2	3
CO4	1	3	3
CO5	1	-	3

MODULE 1

Interferometers – Faby-Perot, Michelson interferometer, Interference filters, optical spectrum analyzer, modulation of light, electro-optic effect, magneto-optic effect and acousto-optic effect

MODULE 2

Lasers- Principle of operation, Einstein relations, population inversion, optical feedback, resonant cavity, laser modes, Q-switching, mode locking, 3 and 4 level systems, properties of lasers.

MODULE 3

Classes of lasers- Solid state, gas lasers, dye lasers and semiconductor lasers, operation and working, lasers applications, holography, industrial biomedical, pollution monitoring

MODULE 4

Optical fiber- Light guidance through fibers, step index fiber, graded index fiber, multi-mode, single mode, numerical aperture, dispersion, losses in fiber, measurement fiber characteristics, OTDR, couplers, splicers, connectors.

MODULE 5

Optical fiber communication system, components, modulation, demodulation, fiber optic sensors, pressure, temperature displacement acceleration strain, fiber bragg grating, photonic band gap materials.

Text Books

1. J. Wilson and J.F Hawkes, Optoelectronics-An introduction, Pentice Hall
2. K. Tyagarajan and A.K.Ghatak, Lasers- Theory and Applications, Springer

24-473- 0215 FRACTIONAL ORDER SYSTEM AND CONTROL

L	T	P	C
3	1	0	3

Pre-requisites: Nil
Total Hours: 64

Course Outcomes:
After completion of this course, the student will be able to

CO1: Understand the fundamentals of fractional-order systems, including the advantages of fractional-order control compared to its integer order counterpart, definitions, properties, and models of fractional-order systems, as well as stability analysis.

CO2: Gain proficiency in state-space representation and analysis techniques for continuous-time LTI commensurate-order systems, including solving state equations, and assessing controllability and observability.

CO3: Develop a deep understanding of fractional-order control theory, including the need for fractional-order control, the design of generalized fractional-order control actions, and the tuning of fractional-order proportional integral derivative (PID) controllers for various plant models.

CO4: Learn the principles of robust control, including the problem statement, H(n) norm, H∞ norm, frequency domain formulation, state-space formulation, robust stabilization, and H2 optimal control.

CO5: Explore non-integer-order robust control techniques, such as CRONE controllers and their different generations, including their definitions, characteristics, and applications in control systems.

Mapping of course outcomes with program outcomes

	CO1	**CO2**	**CO3**	**CO4**	**CO5**
PO 1	3	2	3	2	1
PO 2	3	2	3	2	1
PO 3	3	2	3	2	1

Module 1
Fundamentals of Fractional-order Systems: Advantage of fractional-order system/control over its integer order counterpart, Fractional-order Operators: Definitions and Properties, Fractional-order Differential Equations, Fractional-order Systems-Models and Representations, Stability, Bode’s Ideal Loop Transfer Function as Reference System

Module 2
State-space Representation and Analysis: Continuous-time LTI State-space Models, Solution of the State Equation of Continuous LTI Commensurate-order Systems, Controllability of Continuous LTI Commensurate-order, Observability of Continuous LTI Commensurate-order Systems

Module 3

Fundamentals of Fractional-order Control: Need for Fractional-order Control, Generalized Fractional-order Control Actions, Generalized PID Controller, Fractional-order Proportional Integral Controller Tuning for First-order Plus Delay Time Plants, Fractional-order Proportional Derivative Controller Tuning for Motion Systems, Fractional-order Proportional Integral Derivative Controllers.

Module 4

Robust Control: Definition and problem statement, the H(n) norm, H∞ norm, frequency domain formulation, state space formulation robust stabilization H2 optimal control, H∞ control.
Non-integer-order Robust Control: CRONE, First Generation CRONE Controller, Second Generation CRONE Controller, Third Generation CRONE Controller.

Module 5

Implementations of Fractional-order Controllers: Methods and Tools- Continuous-time Implementations of Fractional-order Operators, Frequency Response Fitting of Fractional-order Controllers, Continuous-time Approximation, Time moments of a transfer function, Markov parameters of a transfer function, approximate generalized time Moments (AGTM) & approximate generalized Markov parameters (AGMP), AGTM and AGTM based approximation of fractional-order system.
Numerical Issues and MATLAB Implementations for Fractional-order Control Systems:
Computations in Fractional Calculus, Fractional-order Transfer Functions, Optimum Controller Design for Fractional-order Systems.
Real Applications: Systems Identification, Position Control of a Single-link Flexible Robot

References:

1. C. A. Monje, Y. Chen, B. M. Vinagre, D. Xue, and V. Feliu-Battle, Fractional-order systems and controls : fundamentals and applications. London: Springer-Verlag London Limited, 2010. (Modules I-V)
2. Astrom .K, Adaptive Control, Second Edition, Pearson Education Asia Pte Ltd. (Module IV).
3. Bultheel, A., & Van Barel, M. (1997). Linear Algebra, Rational Approximation and Orthogonal Polynomials (Vol. 6). North-Holland, Elsevier Science; Amsterdam. (Module V).
4. J. Pal, "An algorithmic method for the simplification of linear dynamic scalar systems," Int. J. Control, vol. 43, no. 1, pp. 257–269, Jan. 1986. (Module V).
5. J. Pal, B. Sarvesh, and M. K. Ghosh, "A new method for model order reduction," IETE J. Res., vol. 41, no. 5–6, pp. 305–311, Sep. 1995. (Module V).
6. Shantanu Das, Functional Fractional Calculus. Berlin, Germany: Springer, 2011. (Module I, II).

24-473-0301 PROJECT PROGRESS EVALUATION

Course Outcome:

At the end of this course, students will demonstrate the ability to:

CO1: Demonstrate aptitude for research and independent learning.

CO2: Demonstrate the ability to carry out a literature survey and select unresolved problems in the domain of the selected project topic.

CO3: Gain the expertise to use new tools and techniques for design and development.

CO4: Develop the ability to write a good technical report, make an oral presentation of the work, and publish the work in reputed conferences/journals.

CO – PO Mapping

PO	CO 1	CO 2	CO 3	CO 4
PO 1	3	3	2	1
PO 2	1	1	1	3
PO 3	2	3	3	2

The Project is aimed at training the students to analyze any problem in the field of Instrumentation systems independently. The project may be analytical, computational or experimental or a combination of them based on the latest developments in the relevant areas. It should consist of objectives of study, scope of work, critical literature review and preliminary work done pertaining to the seminar undertaken in Semester II.

During the project period, every student has to present the progress of their work before the duly constituted committee of internal teachers of the department. The assessment by the committee members is a part of the term Evaluation. A report of the project in the form of a hard copy must be submitted to the office before the final evaluation at the end of the semester

24-473-0401 PROJECT DISSERTATION EVALUATION

Course Outcome:

At the end of this course, students will demonstrate the ability to:

CO1: Demonstrate aptitude for research and independent learning.

CO2: Demonstrate the ability to carry out literature survey and select unresolved problems in the domain of the selected project topic.

CO3: Gain the expertise to use new tools and techniques for the design and development.

CO4: Develop the ability to write good technical report, to make oral presentation of the work, and to publish the work in reputed conferences/journals.

PO	CO 1	CO 2	CO 3	CO 4
PO1	3	3	2	1
PO2	1	1	1	3
PO3	2	3	3	2

The dissertation is a continuation of the project work done by the student during Semester III. The dissertation report is expected to show clarity of thought and expression, critical appreciation of the existing literature and analytical computation and experimental aptitude of the students as applicable. During the dissertation period, every student has to present the progress of their work before the duly constituted committee of Faculty Members of the department. The assessment by the committee members is a part of the term Evaluation. A report of the dissertation in the form of a hard copy must be submitted in the office at least two weeks before the final viva voce is conducted by the evaluation committee.