COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY

COCHIN – 682 022

CURRICULUM AND SYLLABUS

of

M.TECH. DEGREE PROGRAMME IN ELECTRONIC INSTRUMENTATION & CONTROL ENGINEERING

offered by

Department of Instrumentation

Cochin University of Science And Technology

(With effect from 2025 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	25-513-0101	Soft Computing Techniques in Instrumentation	C	3	3	1	-	100
2	25-513-0102	Data Acquisition and Hardware Interfaces	C	3	3	1	-	100
3	25-513-0103	Optimal and Robust Control	C	4	4	1	-	100
4	25-513-0104	Sensor Technology Lab	C	1	-	-	3	50
5	25-513-0105	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. 25-513-0106 Advanced Digital Signal Processing
2. 25-513-0107 Process Dynamics and Control
3. 25-513-0108 Advanced Analytical Instruments
4. 25-513-0109 Optimisation Techniques
5. 25-513-0110 Robotics and Automation
6. 25-513-0111 Non Linear Control Systems
7. 25-513-0112 Advanced Biomedical Instruments
8. 25-513-0113 Adaptive Control Theory

CURRICULUM FOR M.TECH. IN ELECTRONIC INSTRUMENTATION & CONTROL ENGINEERING

SEMESTER II

Sl. No.	Course code	Name of the course	Core/ Elective	Credits	Hours per week			Marks
					L	T	P	
1	25-513-0201	Advanced Multi-sensor Data Fusion	C	3	3	1	-	100
2	25-513-0202	Wireless Sensor Networks	C	3	3	1		100
3	25-513-0203	Seminar	C	1	-	-	3	50
4	25-513-0204	Soft computing Lab	C	1	-	-	3	50
5	25-513-0205	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. 25-513-0206 Digital Image Processing
2. 25-513-0207 Mechatronics
3. 25-513-0208 MEMS and Microsystems
5. 25-513-0209 Optoelectronics and Instrumentation
6. 25-513-0210 Non Destructive Testing and Analysis.
7. 25-513-0211 Navigation Guidance and Control
8. 25-513-0212 Embedded System Design
9. 25-513-0213 Remote Sensing and Geographical Information Systems
10. 25-513-0214 Internet of Things.
11. 25-513-0215 Fractional Order System and Control

CURRICULUM FOR M.TECH. IN ELECTRONIC INSTRUMENTATION & CONTROL ENGINEERING

SEMESTER III

Sl. No.	Course code	Name of the course	Core/Elective	Credits	Marks
1	25-513-0301	Open Elective- I*	E	3	100
2	25-513-0302	Project Progress Evaluation	C	15	400
Total				18	500

CURRICULUM FOR M.TECH. IN ELECTRONIC INSTRUMENTATION & CONTROL ENGINEERING

SEMESTER IV

Sl. No.	Course code	Name of the course	Core/Elective	Credits	Marks
1	25-513-0401	Open Elective - II*	E	3	100
2	25-513-0402	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

SEMESTER I

25-513-0101 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.

Mapping of course outcomes with PO's: **Level - Low (1), medium (2) and high (3)**

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).

25-513-0102 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 PO's: **Level - Low (1), medium (2) and high (3)**

	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.

25-513-0103 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 PO's: **Level - Low (1), medium (2) and high (3)**

	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.

25-513-0104 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 PO's: **Level - Low (1), medium (2) and high (3)**

	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.

25-513-0105 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 PO's: **Level - Low (1), medium (2) and high (3)**

	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

Department of Instrumentation
Cochin University of Science And Technology

First Semester M Tech Electronic Instrumentation & Control Engineering
Elective Subjects

25-513-0106 ADVANCED DIGITAL SIGNAL PROCESSING

L	T	P	C
3	1	0	3

Pre-requisites: Nil
Total Hours: 64

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

CO1: **Apply** fundamental transforms (DFT, FFT, DCT) for efficient signal analysis in various engineering problems.
CO2: **Design** and implement multirate signal processing systems for sampling rate conversion.
CO3: **Perform** spectrum estimation using periodogram and autoregressive methods for analyzing power spectral density.
CO4: **Apply** LMS and RLS algorithms for noise and echo cancellation using adaptive filtering.
CO5: **Implement** DSP algorithms on digital signal processors (DSPs), gaining practical experience with fixed-point and floating-point architectures.

Mapping of course outcomes with program outcomes

	CO1	**CO2**	**CO3**	**CO4**	**CO5**
PO1	3	3	3	3	2
PO2	2	2	2	2	2
PO3	3	3	3	3	3

Module 1

Review of Transforms: Discrete Fourier Transform (DFT), Fast Fourier Transform (FFT) and Discrete Cosine Transform (DCT). Convolution and Correlation. Time frequency analysis and its need. Short time Fourier Transform.

Module 2

Multirate digital signal processing: Basic multirate operations. Efficient structures for decimation and interpolation. Decimation and interpolation and interpolation with polyphase filters. Sampling rate conversion by non-integer factor. Design of practical sampling rate converters. Multirate filtering applications.

Module 3

Spectrum Estimation and Analysis: Principles of spectrum estimation. Periodogram method, modified Periodogram methods, the Blackman-Tukey methods, fast correlation method. Autoregressive spectrum estimation: Autoregressive model and filter. Power spectrum density of AR series. Some practical applications.

Module 4

Adaptive Filtering: Principles of adaptive filtering. Least mean square (LMS) adaptive algorithm its implementation and limitations. Recursive least square (RLS) adaptive algorithm, its implementation and limitations. Basic Wiener filter theory. Applications of adaptive filters in noise cancellations, echo cancellation.

Module 5

Digital Signal Processors: Basic computer architectures for signal processing. General purpose digital signal processors; fixed point digital signal processors and floating point digital signal processors. Implementation of DSP algorithms on general purpose digital signal processors.

References

1. John G. Proakis and Dimitris G. Manolakis, "Digital Signal Processing: Principles, Algorithms, and Applications", 5th Edition, Pearson, 2021.
2. Sanjit K. Mitra, "Digital Signal Processing: A Computer-Based Approach", 4th Edition, McGraw-Hill Education, 2020.
3. P. P. Vaidyanathan, "Multirate Systems and Filter Banks", 2nd Edition, Pearson, 2020.
4. Paulo S. R. Diniz, "Adaptive Filtering: Algorithms and Practical Implementation", 5th Edition, Springer, 2020.
5. M. H. Hayes, "Statistical Digital Signal Processing and Modeling", 1st Edition, Wiley, 2020.

NPTEL course links that align with the syllabus:

1. **Digital Signal Processing and its Applications**
   - **Link**:https://archive.nptel.ac.in/courses/108/101/108101174/
   - **Instructor:** Prof. V. M. Gadre, IIT Bombay
2. **Adv. Digital Signal Processing - Multirate and wavelets**
   - **Link:**https://archive.nptel.ac.in/courses/117/101/117101001/
   - **Instructor:** Prof. V.M. Gadre, IIT Bombay

25-513-0107 PROCESS DYNAMICS 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:	**Describe** the principles of process control and the dynamics of various processes
CO2:	**Apply** knowledge of control system design to classify variables, design elements, and control schemes for different process variables
CO3:	**Understand** the characteristics and sizing of control valves and the response of pneumatic transmission lines.
CO4:	**Apply** performance criteria and control strategies to improve the dynamic behavior of feedback-controlled processes.
CO5:	**Understand** the concepts of Plant-Wide Control

Mapping of course outcomes with program outcomes

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

Module 1

Review of Process and Control Systems: Control Systems, Process control principles, servomechanism, Process control block diagram, identification of elements, Dynamics of liquid process, gas process, flow process, thermal process, mixing process - Batch process and continuous process - Self regulation.

Module 2

Design aspects of Process Control System: Classification of variables, Design elements of a control system, control aspects of a process. The input – output model, degrees of freedom and process controllers. Modes of operation of P, PI and PID controllers. Effect of variation of controller variables. Typical control schemes for flow, pressure, temperature and level processes.

Module 3

Control System components:

I/P and P/I converters - Pneumatic and electric actuators - valve positioner - control valve Characteristics of control valve - valve body - globe, butterfly, diaphragm ball valves - control valve sizing - Cavitation, flashing in control valves - Response of pneumatic transmission lines and valves. Actuators – Pneumatic, Hydraulic, Electrical/ Electronic.

Module 4

Dynamic behavior of feedback controlled process: Stability considerations. Simple performance criteria, Time integral performance criteria: ISE, IAE, ITAE, Selection of type of feedback controller. Logic of feed forward control, problems in designing feedforward controllers, feedback control, Ratio Control, Cascade Control, Override control, auctioneering control, split range control. Processes with large dead time. Dead time compensation. Control of systems with inverse response.

Module 5

Introduction to plant wide control: Plant wide control issues, hypothetical plant for plant wide control issues, internal feedback of material and energy, interaction of plant design and control system design.

References

1. Johnson, C. (2019). *Process Control Instrumentation Technology* (8th ed.). Prentice Hall.
2. Stephanopoulos, G. (2022). *Chemical Process Control: An Introduction to Theory and Practice* (2nd ed.). Prentice Hall.
3. Caughanour, R., & Koppel, L. (2021). *Process Systems Analysis and Control* (3rd ed.). Tata McGraw-Hill Education.
4. Seborg, D. E., Edgar, T. F., & Mellichamp, D. A. (2022). *Process Dynamics and Control* (4th ed.). John Wiley & Sons.
5. Eckman, D. P. (2021). *Automatic Process Control* (4th ed.). Wiley.
6. Harriot, P. (2021). *Process Control* (3rd ed.). Tata McGraw-Hill Education.
7. Patranabis, D. (2019). *Principles of Process Control* (3rd ed.). Tata McGraw-Hill Education.
8. Shinskey, F. G. (2021). *Process Control Systems* (4th ed.). McGraw-Hill Education

NPTEL course links that align with the syllabus:

1. **Introduction to Process Control:** https://nptel.ac.in/courses/103105064
2. **Chemical Process Control:** https://archive.nptel.ac.in/courses/103/101/103101142/#

25-513-0108 ADVANCED ANALYTICAL INSTRUMENTS

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 various x-ray methods of analysis.
CO2:	**Explain** the instrumentation and analysis of different spectroscopic methods.
CO3:	**Outline** the principles and techniques of advanced analytical methods.
CO4:	**Understand** the methods and applications of advanced microscopy techniques.
CO5:	**Understand** the concepts of biosensors, microchip technology, flow injection and HPLC.

Mapping of course outcomes with program outcomes

	CO1	CO2	CO3	CO4	CO5
PO1	2	3	3	2	3
PO2	2	3	3	3	3
PO3	3	3	3	3	3

Module 1
X-ray methods of analysis -Basic principles -Sources -Detectors X-ray absorption methods - X-ray fluorescence technique-X-ray diffraction methods - Electron probe microanalysis.

Module 2
Electron and ion Spectroscopy -X-ray and UV photoelectron spectroscopy -ESCA - Electron impact spectroscopy -Auger electron spectroscopy -Ion scattering spectroscopy - Ion scattering spectroscopy -Rutherford backscattering -0 Principles - Instrumentation and analysis.
Module 3
Advanced topics in magnetic resonance spectrometry -Fourier transform techniques - Nuclear quadruple resonance spectroscopy -Cl3 NMR- 2nd NMR -Advanced topics in mass spectrometry -Quadruple mass analyser- ESR Spectroscopy - Experimental Techniques, Analysis, Applications.

Module 4
Electron microscopy- TEM - SEM -Principles, instrumentation and analysis, Scanning tunneling microscopy, Atomic force microscopy -Principles, instrumentation and analysis - Applications. Photoacoustic and photothermal spectrometers -Principles and instrumentation-spectroflourimeters and phosphorimeters -Electrochemical instruments - Conductivity meters - Coulometers -Amperometers -Radiochemical instruments.

Module 5
Flow injection and sequential injection analysis - Biosensor and microchip technology - Microfluidics Lab on Chip - GLMS Instrumentation - HPLC.

References:

1. R.S. Khandpur(2018) -Handbook of Analytical instruments(3rd Edition) - Tata McGraw Hill Education.
2. Jack Cazes(2018) - Analytical Instrumentation Handbook, (4th Edition)-CRC Press
3. Willard, Merrit, Dean and Settle(2017) -Instrumental Methods of Analysis(8th Edition) Cengage Learning.
4. A. Skoog and M. West(2017) -Principles of Instrumental analysis(7th Edition) -Cengage Learning.
5. Ewing- Instrumental methods of chemical analysis -McGraw Hill.

NPTEL course links that align with the syllabus:

1. **Modern instrumental methods of analysis:** https://archive.nptel.ac.in/courses/103/108/103108100/
2. **Analytical chemistry:** https://onlinecourses-archive.nptel.ac.in/noc18_cy17/preview

25-513-0109 OPTIMIZATION TECHNIQUES

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:	**Demonstrate** proficiency in formulating and solving various optimization problems using classical and modern techniques.
CO2:	**Apply** various optimization techniques to solve constrained and unconstrained problems.
CO3:	**Apply** dynamic programming, multi-objective optimization, and goal programming techniques to solve complex optimization problems with multiple conflicting objectives.
CO4:	**Apply** genetic algorithms to solve optimization problems with stochastic parameters.
CO5:	**Evaluate** the effectiveness of ant colony optimization and particle swarm optimization techniques for solving optimization problems.

Mapping of course outcomes with program outcomes

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

Module 1
Introduction to optimization, functions of single variable, functions of several variables, formulation of optimization problems. Review of classical methods, linear programming, nonlinear programming.

Module 2
Constraint optimality criteria, constrained optimization, constraint direct search method, linearization methods for constrained problems, transformation method. Nonlinear programming: problem formulation, Quadratic Approximation Methods for Constrained Problems Unconstrained minimization techniques.

Module 3
Dynamic programming: sub-optimization, multistage optimization problem. Multi-objective and goal programming: problem formulation, solution of a multi-objective problem. Case studies

Module 4
Introduction to Stochastic Optimization Techniques, types: Local Search, Population Based, Introduction to Genetic Algorithms, Motivation from Nature, Genetic Algorithms: Working Principle: Representation, Fitness Assignment, Reproduction, Crossover, Mutation, Constraint Handling, Real Parameter Genetic Algorithms, Combined Genetic Algorithm, Advanced Genetic Algorithms, Applications.

Module 5

Ant Colony Optimization: Introduction, Ant System, Ant Colony System, ANTS, Significant Problems, Convergence Proofs. Discrete Particle Swarm Optimization (PSO):Introduction, PSO Elements: Position and State Space, Objective Function, Velocity, PSO Algorithm, Examples and Results, Applications.

References:

1. Singiresu S. Rao, 'Optimization Techniques', 4th Edition, 2023, New Age International Publishers.
2. D. P. Kothari and J. S. Dhillon, 'Power System Optimization, 2nd Edition, 2010, Tata McGraw Hill.
3. C. Mohan and Kusum Deep, 'Optimization Techniques, 2nd Edition, 2014, New Age International Publishers.
4. Godfrey C. Onwubolu, B. V. Babu, "New Optimization Techniques in Engineering", 1st Edition, 2007 Springer-Verlag.
5. Marco Dorigo, Thomas Stützle, "Ant colony optimization", 2nd Edition 2004, MIT Press
6. Thomas Wiesi, "Global Opimization Algorithms", ebook. http://www.it-weise.de/.

NPTEL course links that align with the syllabus:

1. **Optimization Techniques:** https://onlinecourses.nptel.ac.in/noc21_me10/preview
2. **Optimization Methods for Engineering Design:** https://onlinecourses.nptel.ac.in/noc23_ce67/preview

25-513-0110 ROBOTICS AND AUTOMATION

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: **Describe** the different generations of robots and their characteristics.

CO2: **Apply** knowledge of hydraulic, pneumatic, and electric drives to determine the horsepower and gearing ratio needed for a robotic system.

CO3: **Analyze** the design considerations for various types of grippers and end effectors in relation to manipulator dynamics.

CO4: **Apply** inverse kinematics techniques to solve problems related to robot motion and path planning.

CO5: **Understand** the role of robots in different manufacturing and non-manufacturing applications and how robot cells are designed

Mapping of course outcomes with program outcomes

	CO1	CO2	CO3	CO4	CO5
PO1	2	3	3	3	2
PO2	1	2	2	2	2
PO3	2	3	3	3	2

Module 1

Basic Concepts: Definition and origin of robotics – different types of robotics – various generations of robots – degrees of freedom – Asimov's laws of robotics – dynamic stabilization of robots.

Module 2

Power Sources and Sensors: Hydraulic, pneumatic and electric drives – determination of HP of motor and gearing ratio – variable speed arrangements – path determination – micro machines in robotics – machine vision – ranging – laser – acoustic – magnetic, fiber optic and tactile sensors.

Module 3

Manipulators, Actuators and Grippers: Construction of manipulators – manipulator dynamics and force control – electronic and pneumatic manipulator control circuits – end effectors – various types of grippers – design considerations.

Module 4

Kinematics and Path Planning: Solution of inverse kinematics problem – multiple solution jacobian work envelope – hill climbing techniques – robot programming languages.

Module 5

Case Studies: Multiple robots – machine interface – robots in manufacturing and nonmanufacturing applications – robot cell design – selection of robots.

References

1. Weiss, M. P., Nagel, R. N., & Odraj, N. G. (2022). *Industrial Robotics: Technology, Programming, and Applications* (3rd ed.). McGraw-Hill Education.
2. Ghosh, A. K. (2017). *Control in Robotics and Automation: Sensor-Based Integration* (2nd ed.). Allied Publishers.
3. Deb, S. R. (2019). *Robotics Technology and Flexible Automation* (2nd ed.). John Wiley & Sons.
4. Asfahl, C. R. (2020). *Robots and Manufacturing Automation* (4th ed.). John Wiley & Sons.
5. Klafter, R. D., Chimielewski, T. A., & Negin, M. (2021). *Robotic Engineering: An Integrated Approach* (2nd ed.). Prentice Hall.
6. McKerrow, P. J. (2021). *Introduction to Robotics: Mechanics and Control* (4th ed.). Pearson.
7. Asimov, I. (2020). *I, Robot* (Reissue ed.). Ballantine Books.

NPTEL course links that align with the syllabus:

1. **Introduction to robotics:** https://nptel.ac.in/courses/107106090
2. **Sensors and Actuators:** https://onlinecourses.nptel.ac.in/noc21_ee32/preview

25-513-0111 NONLINEAR CONTROL SYSTEMS

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: CO2:	**Understand** the concepts of phase plane analysis and describe the behavior of nonlinear systems using phase portraits.
CO3:	**Apply** Lyapunov's direct method to analyze the stability of linear time-invariant systems and design controls based on Lyapunov functions.
CO4:	**Analyze** feedback linearization techniques to convert nonlinear systems into a canonical form and compare input-state and input-output linearization methods for SISO and MIMO systems.
CO5:	**Apply** sliding mode control principles to design sliding surfaces and continuous approximations for switching control laws, and evaluate their performance
	Describe the control strategies used in adaptive robot trajectory control and spacecraft attitude control, highlighting the challenges and solutions in multi-input systems

Mapping of course outcomes with program outcomes

	CO1	CO2	CO3	CO4	CO5
PO1	2	3	3	3	2
PO2	1	2	2	2	2
PO3	2	3	3	3	2

Module 1

Introduction: Nonlinear system behaviour, concepts of phase plane analysis, singular points, constructing phase portraits, phase plane analysis of nonlinear systems, existence of limit cycles, concepts of stability, describing function analysis – assumptions and definitions, describing functions of common nonlinearities.

Module 2

Lyapunov theory: Lyapunov direct method, positive definite functions and Lyapunov functions, invariant set theorems, Lyapunov analysis of linear time invariant systems, the variable gradient method, performance analysis, control design based on Lyapunov's direct method, Lyapunov analysis of non autonomous systems, existence of Lyapunov functions.

Module 3

Feedback Linearization: Feedback linearization and the canonical form, Input – state linearization, input – output linearization of SISO and MIMO systems.

Module 4

Sliding Control: Sliding surfaces, continuous approximations of switching control laws, modeling performance trade offs, VSSC – examples.

Module 5

Control of multi input physical systems: Adaptive robot trajectory control, spacecraft control, attitude control.

References

1. Marino, R., & Tomei, P. (2020). *Nonlinear Control Design: Geometric, Adaptive, and Robust* (2nd ed.). Springer.
2. Slotine, J. J. E., & Li, W. (2020). *Applied Nonlinear Control* (2nd ed.). Prentice Hall.
3. Isidori, A. (2020). *Nonlinear Control Systems* (3rd ed.). Springer.

NPTEL course links that align with the syllabus:

1. **Nonlinear control system:** https://archive.nptel.ac.in/courses/108/106/108106024/
2. **Nonlinear system analysis:** https://archive.nptel.ac.in/courses/108/106/108106162/

25-513-0112 ADVANCED BIOMEDICAL INSTRUMENTS

L	T	P	C
3	1	-	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

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

References

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

25-513-0113 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.

NPTEL course links that align with the syllabus:

1. https://onlinecourses.nptel.ac.in/noc22_me129/preview

SEMESTER II

25-513-0201 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.

Mapping of course outcomes with PO's: **Level - Low (1), medium (2) and high (3)**

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).

25-513-0202 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.

25-513-0203 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 PO's: **Level - Low (1), medium (2) and high (3)**

	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.

25-513-0204 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

Mapping of course outcomes with PO's: **Level - Low (1), medium (2) and high (3)**

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.

25-513-0205 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 PO's: **Level - Low (1), medium (2) and high (3)**

	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

Department of Instrumentation
Cochin University of Science And Technology

Second Semester M Tech Electronic Instrumentation & Control Engineering

Elective Subjects

25-513-0206 DIGITAL IMAGE PROCESSING

L	T	P	C
3	1	0	3

Pre-requisites: Nil

Total Hours: 64

Course Outcomes (COs):

1. **CO1**: **Understand** the fundamentals of digital images, including representation, perception, and basic relationships between pixels.
2. **CO2**: **Apply** image enhancement techniques in both spatial and frequency domains to improve image quality.
3. **CO3**: **Analyze** image restoration techniques, including inverse filtering, Wiener filtering, and geometric transformations.
4. **CO4**: **Explore** various image compression techniques, including JPEG, and wavelet-based methods, and understand redundancy and fidelity criteria.
5. **CO5**: **Understand** different image segmentation methods and colour image processing techniques.

CO-PO Mapping Table:

	CO1	**CO2**	**CO3**	**CO4**	**CO5**
PO1	2	3	3	3	3
PO2	2	2	2	2	2
PO3	3	3	3	3	3

Module 1

Digital Image fundamentals: representation, elements of visual perception, simple image formation model, image sampling and quantization, basic relationship between pixels, imaging geometry.

Review of Matrix theory results: Row and Column ordering, Doubly Block Toeplitz for 2 D linear convolution, Doubly Block Circulant Matrices for circular convolution, Kronecker products, unitary and orthogonal matrices.

Unit**ary Transforms for Image processing:** General unitary Transforms, DFT, DCT, DST, Hadamard Transform, Haar Transform, , Karhunen Loeve Transform.

Module 2

Image Enhancement: Spatial Domain Methods: point processing - intensity transformations, histogram processing, image subtraction, image averaging. Spatial filtering- smoothing filters, sharpening filters, Frequency Domain methods- low pass filtering, high pass filtering, homomorphic filtering, generation of spatial masks from frequency domain specifications

Module 3

Image restoration: Degradation model, Diagonalization of circulant and doubly block circulant matrices, Algebraic approaches- Inverse filtering, Wiener filtering, Constrained Least Squares restoration, Interactive restoration, Geometric transformations.

Module 4

Image Compression: Fundamentals, redundancy: coding, interpixel, psychovisual, fidelity criteria, Models, Elements of information theory, error free compression - variable length, bit plane, lossless predictive, lossy compression- lossy predictive, transform coding, Fundamentals of JPEG image compression, Wavelet based compression techniques- EZW, SPIHT, JPEG 2000.

Module 5

Image Segmentation: Detection of discontinuities- point, line, edge and combined detection, edge linking and boundary description, local and global processing using Hough Transform- Thresholding, Region oriented segmentation – basic formulation, region growing by pixel aggregation, region splitting and merging, use of motion in segmentation.

Color Image Processing: color models- RGB, CMY, YIQ, HIS, Pseudo coloring, intensity slicing, gray level to color transformation.

References:

1. Rafael C. Gonzalez and Richard E. Woods, "Digital Image Processing", 4th Edition, Pearson, 2018.
2. Anil K. Jain, "Fundamentals of Digital Image Processing", 1st Edition, Pearson, 2015.
3. William K. Pratt, "Digital Image Processing", 5th Edition, Wiley, 2021.
4. Tamal Bose, "Digital Signal and Image Processing", 2nd Edition, Wiley, 2019.
5. J. S. Lim, "Two-Dimensional Signal and Image Processing", 1st Edition, Pearson, 2014.
6. S. Jayaraman, S. Esakkirajan, T. Veerakumar, Digital Image Processing, McGraw Hill Education, 1st Edition, 2009.
7. D. Sundararajan, Digital Image Processing: A Signal Processing and Algorithmic Approach, Springer Nature, (2017).
8. Mandal, Jyotsna Kumar and Baidyanath Chakravarty. Digital Image Processing: An Algorithmic Approach, 1st edition, Springer, 2021

NPTEL course links that align with the syllabus:

1. **Digital Image Processing**
   https://archive.nptel.ac.in/courses/117/105/117105135/

2. **Advanced Image Processing**
   https://archive.nptel.ac.in/courses/106/105/106105216/

25-513-0207 MECHATRONICS

L	T	P	C
3	1	0	3

Pre-requisites: Nil

Total Hours: 64

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

1. **CO1**: **Understand** the fundamentals of mechatronic systems, including trends in control systems and microcontroller-based controllers.
2. **CO2**: **Understand** the different sensor systems and signal conditioning circuits for measuring various physical parameters.
3. **CO3**: **Analyze** precision mechanical actuation systems, including pneumatic, hydraulic, and electro-mechanical actuators.
4. **CO4**: **Understand** electro-mechanical drive systems, including stepper motors, DC motors, and variable frequency drives, with appropriate control techniques.
5. **CO5**: **Develop** microcontroller-based interfacing solutions for digital and analog signal processing, and integrate programmable logic controllers (PLC) for multi-axis control.

Mapping of course outcomes with program outcomes

	CO1	**CO2**	**CO3**	**CO4**	**CO5**
PO1	2	3	3	3	3
PO2	2	2	2	2	2
PO3	3	3	3	3	3

Module 1

Introduction: definition, trends, control systems, micro-controller based controllers, PC based controllers.

Module 2

Design of sensor and signal conditioning for Displacement, position, velocity, force, pressure, temperature.

Module 3

Precision mechanical actuation: Pneumatic, Electro-pneumatic, Hydraulic, Electro-hydraulic actuation systems, ball screw and nut, linear motion guides, linear bearings, bearings, harmonic transmission, motor/drive selection.

Module 4

Electro mechanical drives: relays and solenoid, stepper motors, DC-brushed / brushless motors, DC servo motors, breaking methods, PWM, Bi-polar driver, MOSFET drivers, SCR drivers, Variable Frequency Drives.

Module 5

Microcontroller and interfacing: Digital signal interfacing techniques, Analog signal interfacing with ADC and DAC. Programmable logic and motion controller: programming, interfacing of sensors and actuators to PLC, Simultaneous control of axes integration of axes and I/Os.

References

1. Robert H. Bishop, "The Mechatronics Handbook", 2nd Edition, CRC Press, 2018.

2. William Bolton, "Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering", 7th Edition, Pearson, 2021.

3. David G. Alciatore, "Introduction to Mechatronics and Measurement Systems", 5th Edition, McGraw-Hill Education, 2019.

4. Smail Mahmud, "Mechatronics with Experiments", 1st Edition, Springer, 2017.

5. Devdas Shetty and Richard A. Kolk, "Mechatronics System Design", 3rd Edition, Cengage Learning, 2021.

6. Ajay V. Deshmukh, “Microcontrollers: Theory and Applications" Tata McGraw-Hill, 2005.

7. "Instrument Engineers' Handbook" by Bela G. Liptak are as follows:

   Volume 1: Process Measurement and Analysis – 4th Edition (2003, CRC Press)

   Volume 2: Process Control and Optimization – 4th Edition (2005, CRC Press)

   Volume 3: Process Software and Digital Networks – 4th Edition (2018, CRC Press).

NPTEL course links that align with the syllabus:

1. **Mechatronics and Manufacturing Automation**
   https://nptel.ac.in/courses/112103174
2. **Introduction to Robotics**
   https://nptel.ac.in/courses/107106090

25-513-0208 MEMS AND MICROSYSTEMS

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 fundamental concepts of MEMS and Microsystems.
CO2:	**Analyze** the mechanical behavior of microsystems and perform basic finite element stress analysis.
CO3:	**Understand** the properties and applications of various materials used in MEMS.
CO4:	**Understand** various microsystem fabrication processes and micromanufacturing techniques.
CO5:	**Discuss** the principles and applications of RF MEMS and BioMEMS.

Mapping of course outcomes with program outcomes

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

Module 1

Introduction, Planar Vs 3d structures, Microsystem sensors, actuators and fluidics overview, Basics of microsystem engineering- doping, diffusion, plasma physics, electrochemistry.

Module 2

Engineering mechanics of microsystem, Stating bending of thin plates, mechanical vibration, thermomechanics, fracture mechanics, thin film mechanics, basics of finite element stress analysis.

Module 3

Materials for MEMS- substrate and wafers, silicon, properties, silicon compounds, Silicon piezoresistors, gallium arsenide, Quartz, piezoelectric crystals, Polymers, Packaging materials.

Module 4

Microsystem fabrication processes- Photolithography, Ion implantation, diffusion, oxidation, CVD, PVD, Epitaxy, Physical and chemical etching, Micromanufacturing- bulk micromanufacturing, surface micromachining, LIGA process, microsystem packaging.

Module 5

RF MEMS- Basic ideas, Micromachined switches, antennas, inductors, capacitors, BioMEMS- Multi-parameter BioMems for clinical monitoring, neural implants, microfluidic platforms, DNA based systems.

References:

1. "MEMS: A Practical Guide to Design, Analysis, and Applications"(2021), Mohammad I. Younis(1st edition), Wiley.
2. "Introduction to Microelectromechanical Systems Engineering"(2020), N. Maluf, K. Williams(2nd edition), CRC Press.
3. "Fundamentals of Microfabrication: The Science of Miniaturization"(2018), Marc J. Madou(3rd edition), CRC Press.
4. "MEMS and Microsystems: Design and Manufacture"(2017), Tai-Ran Hsu(3rd edition), McGraw-Hill
5. "RF MEMS: Theory, Design, and Technology"(2018), Gabriel M. Rebeiz(2nd edition), Wiley.
6. "BioMEMS: Technologies and Applications"(2013), Gerald A. Urban(1st edition), Springer.

NPTEL course links that align with the syllabus:

1. **A brief introduction of Micro - Sensors:**
   https://onlinecourses.nptel.ac.in/noc24_ee09/preview
2. **MEMS and Microsystems:**
   https://archive.nptel.ac.in/courses/117/105/117105082/

25-513-0209 OPTOELECTRONICS AND INSTRUMENTATION

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** principles of light wave analysis and manipulation using interferometers, filters, analyzers, and modulation techniques
CO2:	**Understand** fundamental principles of laser operation.
CO3:	**Understand** advanced techniques in magnetic resonance and mass spectrometry techniques, analysis, and applications.
CO4:	**Understand** the principles, operation, and applications of various types of lasers.
CO5:	**Understand** the principles of optical fiber communication systems

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	2	2	3	3	3

Module 1

Interferometers – Faby-Perot, Michelson interferometer, Interference filters, Optical spectrum analyzer, Modulation of light, electro-optic, magneto-optic and acousto-optic

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 and dye lasers, operation and working, semiconductor 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.

References:

1. J. Wilson and J.F Hawkes, Optoelectronics-An introduction, Pentice Hall
2. K. Tyagarajan and A.K.Ghatak, Lasers- Theory and Applications, Springer
3. T. Ray, Optoelectronics and Fiber Optics Technology
4. R. Kashyap, Fiber Bragg Grating Academic Press

NPTEL course links that align with the syllabus:

1. **Optoelectronics:**
   https://onlinecourses.nptel.ac.in/noc20_ph24/preview
2. **Fiber Optic Communication Systems:**
   https://archive.nptel.ac.in/courses/108/106/108106167/

25-513-0210 NON DESTRUCTIVE TESTING AND ANALYSIS

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 fundamental principles, theory, and applications of acoustic emission technology.
CO2:	**Apply** various electromagnetic and optical testing methods to assess the integrity and condition of materials and structures.
CO3:	**Solve** multi-objective and goal programming problems using dynamic programming techniques.
CO4:	**Understand** the principles, applications, and limitations of various nondestructive testing methods.
CO5:	**Understand** the principles, applications, and limitations of ultrasonic testing techniques for assessing materials and structures.

Mapping of course outcomes with program outcomes

	CO1	CO2	CO3	CO4	CO5
PO1	3	3	3	3	3
PO2	2	3	3	3	3
PO3	1	2	2	1	1

Module 1

Introduction - Acoustic Emissions- Principles and Theory. Signal Propagation. The AE Process Chain, The AE Measurement Chain, Physical Considerations. Time Considerations. AE Parameters. AE Theory, AE Transducers, Acoustic Emission Sensors and Couplers, AE Sensor Construction. Acoustic Emission Technology, Applications.

Module 2

Electromagnetic Testing Method, Eddy Current Sensing Probes, Flux Leakage Sensing Probes, Alternating Current Field Measurement (ACFM) Method, Calibration and Testing, Laser Testing methods- Profilometry Methods, Holography, Interferometry. Confocal Measurement, Scanning Laser Profilometry, Optical Inspection Systems, Visual and optical testing.

Module 3

Leak Testing Methods- Ultrasonic Leak Testing. Bubble Leak Testing. Dye Penetrant Leak Testing, Pressure Change Leak Testing, Mass Spectrometer Leak Testing, “Sniffer” Techniques, Liquid Penetrant Tests, Magnetic Particle Testing.

Module 4

Neutron Radiographic Testing, Radiographic Testing Method, Industrial Radiography, Portable Linear Accelerators, Fluoroscopy Techniques. Thermal/Infrared Testing Method, Heat and Light Concepts. Color Change Thermometry Infrared Imaging Systems.

Module 5

Ultrasonic Testing - Non Contacting Ultrasonic Testing, Ultrasonic Pulsers/Receivers, Multilayer Ultrasonic Thickness Gauge. Time-of-Flight Diffraction, Vibration Analysis Method, Principles/Theory. Stress Analysis, Vibration Analysis/Troubleshooting, Impact Testing and Frequency Response, Machine Diagnosis

References:

1. Introduction to Nondestructive Testing: A Training Guide, 2nd Edition, Paul E. Mix, Wiley, 3rd Edition, 2019
2. Practical Non-destructive Testing, Baldev Raj, T. Jayakumar, M. Thavasimuthu, 2nd Edition, Woodhead Publishing, 2015.
3. Nondestructive Testing of Deep Foundations - Bernard Hertlein , Allen Davis, 2006, Publisher John Wiley and Sons Ltd
4. Theory and Practice of Infrared Technology for Nondestructive Testing - Xavier P. V. Maldague, 2001 , Publisher John Wiley & Sons Inc
5. NDT Data Fusion - Xavier Gros, Publisher ELSEVIER SCIENCE & TECHNOLOGY, 1996

NPTEL course links that align with the syllabus:

1. **Theory and Practice of Non Destructive Testing:** https://archive.nptel.ac.in/courses/113/106/113106070/
2. **Inspection and Quality Control in Manufacturing:** https://onlinecourses.nptel.ac.in/noc23_me47/preview

25-513-0211 NAVIGATION GUIDANCE 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 longitudinal and lateral dynamics of aircraft, including displacement autopilot, pitch rate feedback, and glide slope control systems.
CO2:	**Analyze** the missile control systems and the dynamics and control of rigid and elastic rockets, including control-structure interactions.
CO3:	**Describe** various navigation methods, including terrestrial, celestial, radio, satellite-based, and inertial navigation systems.
CO4:	**Understand** the guidance principles of radar systems, command and homing guidance systems, and optimal guidance laws.
CO5:	**Apply** control design techniques, including classical methods, pole assignment, optimal control, LQR, and Kalman filters, to the control of aerospace vehicles

Mapping of course outcomes with program outcomes

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

Module 1

Modeling and dynamics of Aircraft: Longitudinal dynamics –displacement autopilot- pitch rate feedback for damping- control stick steering acceleration control system – Glide slope control system. Lateral dynamics of an Aircraft, Yaw damper- Method of obtaining coordination- beta feedback-beta beta dot feedback – acceleration feedback. Yaw orientational control system- Roll angle control system - Landing.

Module 2

Dynamics of Aerospace vehicles: Missiles Missile Control Systems; Dynamics and Control of Rigid and Elastic Rockets; Control-Structure Interaction; Longitudinal and Lateral Autopilots for Rigid Aircraft;

Module 3

Navigation: Terrestrial navigation, Celestial navigation, Terrestrial radio navigation, satellite based navigation, inertial navigation, Integrated Navigation.

Module 4

Guidance: Introduction to Guidance, Navigation and Avionics; Radar Systems, Command and Homing Guidance Systems. Mission consideration and analysis of flight path, Optimal guidance Laws, Inertial Guidance

Module 5

Control of Aerospace Vehicles: Design of Controllers for Aerospace Vehicles; Classical, Pole assignment, EigenStructure Assignment, Optimal Control, LQR, LQG/LTR, Observers and Kalman Filters

References

1. Garnell, P. (2022). *Guided Weapon Control Systems* (2nd ed.). Elsevier.
2. Blakelock, J. H. (2022). *Automatic Control of Aircraft and Missiles* (2nd ed.). John Wiley & Sons.
3. Greensite, A. L. (2021). *Analysis and Design of Space Vehicle Flight Control Systems* (3rd ed.). CRC Press.
4. Skolnik, R. E. (2020). *Introduction to Radar Systems* (4th ed.). McGraw-Hill Education.
5. Lin, C. F. (2021). *Modern Guidance, Navigation, and Control Processing* (2nd ed.). Prentice Hall.
6. D'Azzo, J. J., & Houpis, C. H. (2020). *Linear Control System Analysis and Design* (5th ed.). McGraw-Hill Education.
7. Maceijowski, J. (2021). *Multi-Variable Feedback Design* (2nd ed.). Cambridge University Press.
8. Sinha, A. (2022). *Linear Systems: Optimal and Robust Control* (2nd ed.). CRC Press.
9. Naidu, D. S. (2022). *Optimal Control Systems* (2nd ed.). CRC Press.
10. Hofmann-Wellenhof, B., Legat, K., & Wieser, M. (2021). *Navigation: Principles of Positioning and Guidance* (5th ed.). Springer.

NPTEL course links that align with the syllabus:

1. **Introduction to Aircraft Control System:** https://onlinecourses.nptel.ac.in/noc24_ae05/preview
2. **Aircraft Stability and Control:** https://onlinecourses.nptel.ac.in/noc22_ae10/preview

25-513-0212 EMBEDDED SYSTEM DESIGN

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 architecture, programming, and selection criteria of microcontrollers.
CO2:	**Understand** the architecture of single-purpose processors and general-purpose processors.
CO3:	**Understand** real-time operating system (RTOS) concepts to embedded system design, including task scheduling, synchronization, and device drivers.
CO4:	**Implement** system designs using the 8051 microcontroller, including understanding its instruction sets, addressing modes, and application in system design.
CO5:	**Design** system using AVR microcontrollers, particularly the AtXmega 128A1, focusing on its CPU, external bus interface, power management, and interrupt handling.

Mapping of course outcomes with program outcomes

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

Module 1

Introduction to embedded systems: Categories of embedded systems, overview of embedded system architecture, Microcontroller programming and structured design, Factors to be considered in selecting a microcontroller, recent trends in embedded systems.

Module 2

Plug-in data acquisition boards:
Custom Single purpose Processor: RT level combinational components, RT level sequential components. Custom single purpose processor design; RT level Custom single purpose processor design, General purpose processor: basic architecture, data path, control module.

Module 3

Real Time Operating System (RTOS) based Embedded System Design: Operating system basics, Types of operating systems, Tasks, process and threads, Multiprocessing and Multitasking, Task scheduling, Threads, processes and scheduling: putting them altogether, Task communication, Task synchronization, Device Drivers, How to choose an RTOS.

Module 4

Overview of 8051 microcontrollers: Internal architecture, signals, I/O ports, memory organization & interfacing,timing and control, and port operations. The 8051 instruction sets, interrupts, and timers and counters. Designing with 8051, Programming with 8051 microcontroller, different addressing modes supported by 8051 microcontroller. Some examples of system design using 8051/8052 microcontroller.

Module 5

Introduction to AVR family of microcontrollers, Introduction to AtXmega 128A1 Microcontroller, AVR CPU, EBI- external bus interference, DMAC, system clock and clock option, Power management, Programmable multilevel interrupt controller, I/O ports, instruction set. Design examples using AtXmega128A1.

References:

1. "Embedded Systems Design: An Introduction to Processes, Tools, and Techniques"(2022), David C. Black, John Donovan, John R. Bennett(2nd edition), Springer.
2. "Embedded Systems: A Contemporary Design Tool"(2021), James K. Peckol(2nd edition), Wiley.
3. "Embedded Systems Architecture: A Comprehensive Guide for Engineers and Programmers"(2021), Tammy Noergaard(2 nd edition), Morgan Kaufmann.
4. "Introduction to Embedded Systems: Interfacing to the Internet of Things (IoT)"(2022), David Russell(2 nd edition), CRC Press.
5. "Introduction to Embedded Systems"(2017), Shibu K V(2nd edition), Tata McGraw Hill.
6. "Embedded C Programming and the Atmel AVR"(2006), Barnett R, O'Cull L, Cox S(2nd edition), Thomson Delmar Learning, Canada
7. "The 8051 Microcontroller and Embedded systems"(2005), Mazidi M L, Mazidi J G, Mckinlay R D(2nd edition), Pearson Education Inc, New Delhi.
8. "Embedded System Design- A Unified Hardware/ Software Introduction"(2001), Frank Vahid and Tony Givargis(1st edition), John Wiley & Sons.
9. X-Mega- A Manual"- Atmel Corporation.

NPTEL course links that align with the syllabus:

1. **Introduction to Embedded systems:**
   https://onlinecourses.nptel.ac.in/noc24_cs33/preview
2. **Embedded system design with ARM:**
   https://onlinecourses.nptel.ac.in/noc24_cs24/preview
3. **Embedded System Design:**
   https://onlinecourses.nptel.ac.in/noc23_cs54/preview

25-513-0213 REMOTE SENSING AND GEOGRAPHICAL INFORMATION SYSTEMS

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:	**Describe** Remote Sensing concepts, physical fundamentals and components and adequately use vocabulary, terminology and nomenclature of the discipline.
CO2:	**Compute** an image visually and digitally with digital image processing techniques.
CO3:	**Explain** the concepts and fundamentals of GIS
CO4:	**Explain** technical issues related to digital representation of geographic data and data quality and standards
CO5:	**Apply** knowledge of GIS and understand the integration of Remote Sensing and GIS

Mapping of course outcomes with program outcomes

CO	CO1	CO2	CO3	CO4	CO5
PO1	3	3	3	3	3
PO2	3	3	3	3	3
PO3	2	3	2	2	3

Module 1

Remote Sensing:
Aerial photography and photogrammetry: basic principles, photographic systems, visual interpretation and mapping. Ground truth verification radiometer and its application.

Basic concepts of remote sensing: Idealized remote sensing system. Physics of remote sensing, electromagnetic spectrum, black body concept, atmospheric windows, geometry of scanners, CCD arrays and platforms, history of space imaging characteristics of space platforms like LANDSAT, SPOT, IRS, etc. Characteristics of sensors like MSS, TM, LISS I and LISS II. Outputs from various sensors.

Module 2

Classification of digital data and information:

Supervised, unsupervised. Extraction procedure for different applications and terrain valuation. Thematic interpretation, transfer of interpreted thematic information to base map. Ground verification.

Application of remote sensing: Civil Engineering, Earth Science, Forestry, Agriculture, Oceanography, Fisheries, Water resources, Town planning and land use/land cover mapping.

Module 3

Geographic Information System:
Introduction: Map and use of maps through time, thematic and multiple theme maps, Development of GIS as an introduction and decision making systemAn Overview of GIS: Definition, Objectives and basic concepts, Contributing disciplines and technologies.

Module 4

Digital Representation of Geographic Data:
Technical issues related to digital representation of geographic data, Data quality and standards, Assessment of data quality, Managing spatial errors, Data standards and GIS development. Components of GIS: Computer hardware, peripherals and software

Module 5

Integration of Remote Sensing and GIS:
Extracting metric information from Remotely Sensed images, Extracting thematic information from Remotely Sensed images, Integration of information from remote sensing in GIS . GIS application areas.

References:

1. Paul R Wolf , Elements of photogrammetry –- Mc Graw-Hill
2. Lille sand & Kiefer, Remote sensing and image interpretation, John Wiley and Sons
3. Floyd F. Sabins Remote sensing principles and interpretation - - WH Freeman & Co.
4. John R Jensen, Introductory digital image processing - - Prentice Hall
5. George Joseph, Fundamentals of Remote Sensing- -Universities Press-Technical
6. L R A Narayan Remote Sensing and its Applications- - Universities Press-Science/Reference
7. M. Anji Reddy, Remote Sensing and Geographic information systems – BS Publishers.

NPTEL course links that align with the syllabus:

1. **Introduction to Remote Sensing:** https://archive.nptel.ac.in/courses/121/107/121107009/
2. **Remote Sensing Essentials:** https://archive.nptel.ac.in/courses/105/107/105107201/

25-513-0214 INTERNET OF THINGS

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 IoT technologies, including networking basics, IoT platforms, and Linux network configuration.
- **CO2:** **Understand** the IoT architecture, including protocols, physical layers, and security aspects.
- **CO3:** **Understand** the process of developing IoT applications using various protocols and technologies.
- **CO4:** **Analyse** advanced IoT applications and solutions in real-world scenarios, including home automation, industrial applications, and use of big data.
- **CO5:** **Evaluate** design constraints and performance issues in IoT systems, addressing aspects such as security, privacy, and integration with embedded systems.

Mapping of course outcomes with program outcomes

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

Module 1

Internet/Web and Networking Basics: OSI Model, Data transfer referred with OSI Model, IP Addressing, Point to Point Data transfer, Point to Multi Point Data transfer & Network Topologies, Sub-netting, Network Topologies referred with Web, Introduction to Web Servers, Introduction to Cloud Computing.

IoT Platform overview: Overview of IoT supported Hardware platforms such as: Raspberry pi, ARM Cortex Processors, Arduino and Intel Galileo boards.Network Fundamentals: Overview and working principle of Wired Networking equipment's – Router, Switches, Overview and working principle of Wireless Networking equipment's – Access Points, Hubs etc. Linux Network configuration Concepts: Networking configurations in Linux Accessing Hardware & Device Files interactions.

Module 2

IoT Architecture: History of IoT, M2M – Machine to Machine, Web of Things, IoT protocols - M2M Area Network Physical Layers - IEEE 802.15.4 - The IEEE 802 Committee Family of Protocols -The Physical Layer - The Media-Access Control Layer - Uses of

802.15.4 - The Future of 802.15.4: 802.15.4e and 802.15.4g. The Layering concepts, IoT Communication Pattern, IoT protocol Architecture, The 6LoWPAN Security aspects in IoT. **Applications:** Remote Monitoring & Sensing, Remote Controlling,Performance Analysis.

Module 3

Application Protocols: MQTT, REST/HTTP, CoAP, MySQL.

Back-end Application Designing: Apache for handling HTTP Requests, PHP & MySQL for data processing, MongoDB Object type Database, HTML, CSS & jQuery for UI Designing, JSON lib for data processing, Security & Privacy during development, Application development for mobile platforms: Overview of Android / IOS App Development tools.

Module 4

Case Study & advanced IoT Applications: IoT applications in home, infrastructures, buildings, security, Industries, Home appliances, other IoT electronic equipments. Use of Big Data and Visualization in IoT, Industry 4.0 concepts. Sensors and sensor Node and interfacing using any Embedded target boards (Raspberry Pi / Intel Galileo/ARM Cortex/ Arduino).

Module 5

Key Applications of The Internet of Things: Real World Design Constraints - Smart Metering Advanced Metering Infrastructure - e-Health Body Area Networks - City Automation - Automotive Applications - Home Automation - Smart Cards - Tracking (Following and Monitoring Mobile Objects) - Over-The-Air-Passive Surveillance Ring of Steel - Control Application Examples - Industrial Automation- Smart Cities.

References:

1. “Internet of Things”(2018), Rajkumar Buyya and Amir Vahid Dastjerdi(1 st edition), Springer.
2. "Introduction to Embedded Systems: Interfacing to the Internet of Things (IoT)"(2022), David Russell(2 nd edition), CRC Press.
3. Internet of Things (A Hands-on-Approach)(2014) , Vijay Madisetti , Arshdeep Bahga.(1st edition).
4. Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems(2014), Dr. Ovidiu Vermesan, Dr. Peter Friess(1 st edition), River Publishers.
5. Designing the Internet of Things(2013) , Adrian McEwen (Author), Hakim Cassimally(1 st edition), Wiley.
6. Designing The Internet of Things : Adrian Mcewen, Hakin Cassimally , Wiley- India, 2013.
7. 6LoWPAN: The Wireless Embedded Internet(2011), Zach Shelby, Carsten Bormann(1 st edition), Wiley
8. The Internet of Things: From RFID to the Next-Generation Pervasive Networked(2011) Lu Yan, Yan Zhang, Laurence T. Yang, Huansheng Ning(1 st edition), CRS Press.
9. Computer Networks(2011); By: Tanenbaum, Andrew S(4th edition); Pearson Education Pte. Ltd., Delhi.
10. Interconnecting Smart Objects with IP: The Next Internet, Jean-Philippe Vasseur, Adam Dunkels, Morgan Kuffmann.
11. Asoke K Talukder and Roopa R Yavagal, “Mobile Computing,” Tata McGraw Hill,

2010.

NPTEL course links that align with the syllabus:

1. **Introduction to internet of things:** https://onlinecourses.nptel.ac.in/noc21_cs17/preview
2. **Design for internet of things:** https://onlinecourses.nptel.ac.in/noc21_ee85/preview
3. **Introduction to Industry 4.0 and Industrial Internet of Things:** https://onlinecourses.nptel.ac.in/noc24_cs95/preview

25-513- 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).

NPTEL Suggestions

1. **Control Engineering:**
   https://archive.nptel.ac.in/courses/108/106/108106098/

2. **Integral Transforms and their Applications:**
   https://onlinecourses.nptel.ac.in/noc20_ma41/preview

25-513-0301 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.

Mapping of course outcomes with PO's: **Level - Low (1), medium (2) and high (3)**

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

25-513-0401 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.

Mapping of course outcomes with PO's: **Level - Low (1), medium (2) and high (3)**

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.