# Final Year B. Tech. (Instrumentation and Control) Semester – II

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Teaching Scheme Hours/Week</th>
<th>Examination Scheme</th>
<th>Marks</th>
<th>Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>IN 4201</td>
<td>Process Analytics</td>
<td>Lecture: 3</td>
<td>Tutorial: 0</td>
<td>Practical: 0</td>
<td>50</td>
</tr>
<tr>
<td>PEIN 4201</td>
<td>Program Elective-I</td>
<td>Lecture: 3</td>
<td>Tutorial: 0</td>
<td>Practical: 0</td>
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</tr>
<tr>
<td>OE 4201</td>
<td>Open Elective-II</td>
<td>Lecture: 3</td>
<td>Tutorial: 0</td>
<td>Practical: 0</td>
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</tr>
<tr>
<td>IN 4202</td>
<td>Process Analytics Lab</td>
<td>Lecture: 0</td>
<td>Tutorial: 0</td>
<td>Practical: 2</td>
<td>0</td>
</tr>
<tr>
<td>IN 4203</td>
<td>Project Phase-II</td>
<td>Lecture: 0</td>
<td>Tutorial: 2</td>
<td>Practical: 16</td>
<td>100</td>
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<tr>
<td>IN 4204</td>
<td>Project based Online Course*</td>
<td>Lecture: 2</td>
<td>Tutorial: 0</td>
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<td>Lecture: 11</td>
<td>Tutorial: 2</td>
<td>Practical: 18</td>
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**The student shall register and complete the project based online course preferably in semester-1 but may complete the same till the end of semester-II.**

**PEIN 4201: Program Elective-I**
- A. Process Modelling and Optimization
- B. Digital Control
- C. Building Automation
- D. Power Plant and Safety Instrumentation

**OE 4201: Open Elective-II**
- A. Instrumentation in Agriculture and Food Industry
- B. Advanced Digital Signal and Image Processing
- C. System On Chip
IN 4201: Process Data Analytics

Teaching Scheme
Lecture: 3 Hr/Week

Examination Scheme
In Semester: 50 Marks
End Semester:50 Marks
Credit: 3

Prerequisite: Concepts of Mathematics and Computational techniques

Course Objectives:
1. To explore the statistical analysis techniques for various kinds of data.
2. To understand the concepts and types of Artificial Intelligence and Machine Learning Algorithms.
3. To be familiar with a set of well-known supervised, semi-supervised and unsupervised learning algorithms.

Course Outcomes: The student will be able to
1. apply standard statistical inference procedures to draw conclusions from data analysis.
2. list and define the basic concepts of artificial intelligence and machine learning.
3. compare and select various machine learning algorithms for solving practical problems.
4. implement various machine learning algorithms to different domains.

Unit 1: Introduction to statistical analysis
Statistical Analysis, introduction, methods, definitions Descriptive Statistics, Probability distributions Inferential Statistics, Two Sample Tests, Type 1 and Type 2 Errors Inferential Statistics through hypothesis tests, Permutation & Randomization Test ANOVA and Test of Independence

Unit 2: Regression Analysis and related tools
Introduction, Methods, Types. Linear and Multiple Regression Methods Regression : Ordinary Least Squares, Ridge Regression, Lasso Regression, K Nearest Neighbours Regression & Classification ANOVA and Test of Independence Introduction to R and Python programming Introduction to Advanced Pattern Recognition

Unit 3: Introduction to Artificial Intelligence and Machine Learning
Introduction to machine learning and concepts and comparison with biological intelligence. Differentiating algorithmic and model based frameworks. Introduction to Neural Networks and Fuzzy Logic as techniques for Machine Learning

Unit 4: Supervised Learning Methods
Bias-Variance Dichotomy, Model Validation Approaches, Logistic Regression, Linear Discriminant Analysis, Quadratic Discriminant Analysis, Regression and Classification Trees, Support Vector Machines, Deep Learning

Unit 5: Unsupervised Learning Methods
Clustering, Associative Rule Mining, Introduction to Big Data and Challenges for big data analytics

Unit 6: Classifiers
Cases Studies of Classifiers implemented by various methods for applications in the field of Process Industry, Biomedical Field, Network domain and similar other domains
Text Books:
2. An Introduction to R, by Venables and Smith and the R Development Core Team.
3. Data Analysis and Graphics Using R: An Example-based Approach, by John Maindonald and
4. Sheldon M. Ross, "Introduction to Probability and Statistics for Engineers and Scientists", 4th

Reference Books:
6. Shai Shalev-Shwartz, Shai Ben-David, "Understanding Machine Learning: From Theory to
PEIN 4201(A): Process Modeling and Optimization

Teaching Scheme
Lecture: 3 Hr/Week

Examination Scheme
In Semester: 50 Marks
End Semester: 50 Marks
Credit: 3

Prerequisite: Process Instrumentation, Automatic Control System, Control system Design

Course Objectives:
1. Understand and develop system’s mathematical models.
2. Learn the use of Numerical methods in solving the model equations.
3. To learn to various optimization techniques.

Course Outcomes: The student will be able to
1. define and list types of mathematical models.
2. develop mathematical model of process.
3. simulate and analyze the system performance.
4. apply the optimization techniques and analyze the results.

Unit 1: Modeling Aspects & Mathematical Models (06)
Definition of process model, physical and mathematical modeling, deterministic and stochastic process. Introduction, uses of mathematical models, classification of mathematical methods, scope of coverage, principles of formulation, fundamental laws, continuity equations, energy equations, equation of motion, transport equation, equation of state, equilibrium, kinetics

Unit 2: Mathematical Modeling of Mechanical & Chemical Engineering Systems (06)
Process models of some typical systems in differential equations form, , dead time, first and second order models, higher order models, Behaviour of first order and second order system

Unit 3: Mathematical Models (06)
Mathematical Models of Tanks in series, Tanks in parallel Reaction dynamics, Modeling the chemical reactions, CSTR models, Plug flow reactor model, modeling of flash drum, distillation columns, evaporators, dryers, heat exchangers.

Unit 4: Basic concept of Optimization (06)
Optimization: Concept, need, Essential features of optimization Problem, Concepts of objective functions, Equality and Inequality Constraints, Payback period, Return of Investment, Net present Value, Internal Rate of Return. Classification of optimization problem based on Existence of constrains, Nature of design variables, Physical Structure of the problem, Equation Involved, Permissible values, of design variable, Deterministic Nature of the variables, separability of the variable. Number of objective functions. Continuity of functions, Convex and Concave functions, Convex Region, Extremum of the objective functions, quadratic approximation, Feasible region.

Unit 5: Optimization of Unconstrained Functions & Linear Programming (06)
One-Dimensional search numerical methods for optimizing a function of one variable, scanning and bracketing procedures, Newton, Quasi-Newton and Secant methods, Runge Kutta method.

Unit 6: Unconstrained Multivariable Optimization (06)
Simplex method, Direct Methods, Indirect
Methods, Steepest Descent method.
Linear Programming : Basics of Linear Programming, Simplex Algorithm

**Text Books:**

**Reference Books:**
PEIN 4201(B): Digital Control

Teaching Scheme
Lecture: 3 Hr/Week

Prerequisites: Basics of Control System

Course Objectives:
1. To learn and understand control system design.
2. Design various digital controllers and study the response of those controllers.
3. To learn and understand stability of system in z-plane.
4. Introduce optimal control design and it's need.

Course Outcomes: The student will be able to
1. analyze system design in various planes S-W-Z and its mapping.
2. analyze stability of a system in S-plane and Z-plane
3. design and analyze system using classical method and state space.
4. design optimal control for a discrete system.

Unit 1: Introduction to Discrete Time Control System
Basic building blocks of Discrete Time Control system, Sampling Theorem, Choice of Sampling
Rate and Multirate Sampling, Z Transform and Inverse Z Transform for applications for solving
Differential Equations, Impulse Sampling, Reconstruction: Data Hold, Mathematical Model of Zero
Order Hold

Unit 2: Pulse Transfer Function and Digital Controllers
The Pulse Transfer Function, Pulse Transfer Function of Open Loop and Closed Loop Systems,
Pulse Transfer Function of Digital PID Controller, Velocity and Position forms of Digital PID
Controller, Deadbeat Response and Ringing of Poles, Design of Deadbeat Controller.

Unit 3: Stability Analysis of Discrete Time Control System
Stability regions in S-plane, W-plane and Z-plane and Mapping between the three planes, Stability

Unit 4: Design of Discrete Time Control System- State Space Approach
Different Canonical forms, Relation between State Equations and Pulse Transfer Function, Solution
of Discrete Time State Space Equations, Cayley-Hamilton Theorem, Discretization of Continuous
Time State Equation, Pulse Transfer Function Matrix, Eigen Values, Eigen Vectors and Matrix
Diagonalization.

Unit 5: Pole Placement and Observer Design
Concept of Controllability and Observability, Pole Placement Design by State Feedback, Design of
feedback gain matrix using sufficient condition, Ackerman's formula, State Observers Types.

Unit 6: Introduction to Optimal Control
Basics of Optimal Control, Performance Indices, Quadratic Optimal Control and Quadratic
Performance Index.
Text Books:

Reference Books:
PEIN 4201(C): Building Automation

Teaching Scheme
Lectures: 3 Hr/Week

Examination Scheme
In Semester: 50 Marks
End Semester: 50 Marks
Credit: 3

Prerequisite: Basics of Electronics and Instrumentation

Course Objectives:
1. To understand building automation systems
2. To understand the working of various building automation components.
3. To learn the building automation with applications.

Course Outcomes: The student will be able to
1. interpret and investigate the system requirements for BAS systems.
2. classify, compare and choose the suitable BAS systems for the applications.
3. articulate the purpose and operation of HVAC system components.
4. analyze and validate the design of BAS systems.

Unit 1: Introduction to Building Automation Systems
Intelligent building, Intelligent architecture and structure, Facilities management vs. intelligent buildings. Lifecycle of building, Evolution of intelligent buildings. BAS System Hierarchy – Field level components, Direct Digital Control (DDC), Supervisory Controller, Server, Operator Workstation (OWS). Different systems in BAS which includes HVAC, security, fire, lighting systems. Importance of each system in BAS. Process of BAS design, Role of different stakeholders (Architect, contractor, consultant, application engineer and engineer) in BAS system design. Comfort parameters for human being- temperature, humidity, flow, pressure, clean air, CO2%.

Unit 2: Fire Alarm Systems I

Unit 3: Fire Alarm Systems II
FAS types and Architectures, FAS Loops and classification, comparison of loops, FAS Communication Protocols, Various Fire Standards, Power Supply and voltage drop Calculations, Cause & Effect matrix.

Unit 4: Security Systems
Unit 5: HVAC Water Systems
Design, working of different types of chilled water system- single chiller system, series chiller system, parallel chiller system. Working of different components of chilled water system- decoupler line, bypass line, primary circuit, secondary circuit, and condenser pumps. Concept of free cooling-direct waterside, series waterside, parallel waterside free cooling.
Hot Water Systems: Concept of geothermal system, Working, design of different types of hot water system- with boilers, heat exchanger with steam input, heat exchanger with hot water input, geothermal system, solar system and combination of all listed systems.

Unit 6: HVAC Air Systems
Concept of Air handling unit. Design, working of different components in AHU- damper, filter, cooling coil, heating coil, fan, heat recovery wheel, humidifier. Working, configuration, characteristics for different types of dampers. Damper Sizing, Design and working of different types of AHU. Operation of different modes. Concept of Variable Air Volume (VAV) system-Design, working, use of different types of VAV- CAV, Design, working, use of radiation coil, chilled beam, CRAC unit, VRV systems, unit heater, Fan coil unit and unit ventilator.

Text Books:
3. Benantar M., Access Control System
6. James E. Brumbaugh “HVAC Fundamentals”, volume 1 to 3
7. “Basics of Air Conditioning” ISHRAE, Indian Society of Heating, Refrigerating & Air Conditioning Engineers (product code: B0004 for online shopping)

Reference Books:
1. “All About AHU’s”, ISHRAE. Indian Society of Heating, Refrigerating & Air Conditioning Engineers (product code: B0005 for online shopping)
2. “Chillers Basics”, ISHRAE. Indian Society of Heating, Refrigerating & Air Conditioning Engineers (product code: B0009 for online shopping)
PEIN 4201 (D): Power Plants and Safety Instrumentation

Teaching Scheme
Lectures: 3 Hr/Week

Examination Scheme
In Semester: 50 Marks
End Semester: 50 Marks
Credit: 3

Course Prerequisite: Basics of process control fundamentals, knowledge of Unit operations and basics of control strategies

Course Objectives:
1. To expose the students to the detail process of various types of power plants.
2. To impart knowledge on various measurements and instrumentation involved in various types of power plants.
3. To provide the knowledge on specific measurement techniques and control systems practiced in boiler and turbine units.

Course Outcomes: The student will be able to
1. identify the different unit operations, process control equipments involved in different types of power plants like thermal, nuclear and hydroelectric power plants
2. select appropriate measurement techniques for measurement of various process parameters involved in power plants
3. analyze and develop various control loops for processes involved in power plants
4. assess various automation tools to develop automation strategy to Thermal power plant

Unit 1: Introduction to thermal power plant
Thermal power plant process: Coal and ash circuit, Air and flue gas circuit, Water and steam circuit, Water treatment plant, DM plant, cooling water circuit
Main equipments: Boiler, steam turbines, generator, boiler feed pump, condensate extraction pump, deaerator etc
Measurements in power plants and sensors used: Measurement of feed water flow, air flow, steam flow and coal quantity, drum level measurement, Steam pressure and temperature measurement, flue gas analyzer, fuel composition analyzers, flame monitoring, Turbine speed and vibration measurement

Unit 2: Boiler and Turbine Controls
Boiler control: steam pressure control with load index, coal mill control, furnace draft control, drum-level controls, super heater temperature control, fuel/air ratio, oxygen, CO and CO2 trimming, combustion efficiency, excess air, parallel and cross limited combustion control.
Turbine control: Turbine speed and load control, transient speed rise, automatic load frequency control, Turbine oil cooling system, Turbine run up system, Thermal stress control, Vibration, eccentricity, axial shift.
Instrumentation in Generator cooling systems, Generator control system

Unit 3: Application of DCS in Thermal power plant control
Automation strategy, Automatic boiler control, diagnostic functions and protection, Electro-hydraulic governor system, Automatic startup system, Distributed control to improve reliability
Need of condition monitoring systems, Fault tolerant control system in thermal power plants
Unit 4: Nuclear power plant
Nuclear power plant method of power generation, Basic physics of nuclear reactors Atomic structure, isotopes, radioactivity, basics of fission reaction, moderation, criticality Components of nuclear reactor Radiation sources and protection safety objectives Rad-waste management Safety Practices in Indian NPPS, Radiological Protection to workers and public, Dose limits, Health physics

Unit 5: Nuclear power plant Instrumentation
Control loops for different types of nuclear reactors, Process sensors for nuclear power plants for radiations detection, temperature measurement etc, Safety in nuclear power plant, reliability aspects

Unit 6: Hydroelectric power plant Instrumentation
Hydroelectric power plant process, Types of water turbines, Governing system in water turbine of hydro power plant, Regulation & monitoring of voltage & frequency of output power, Electrical substation controls, SCADA solution to improve reliability, Safety system in hydro power, Pollution & effluent monitoring & control, Energy Management

Text Books:
1. Power Plant Instrumentation, K. Krishnaswamy, M. Ponnibala
2. Computer Based Industrial Control, Krishna Kant
3. Power Plant Engineering, Domkundwar
4. Power Plant Engineering, Manoj Kumar Gupta

Reference books:
2. Process Control, Liptak
4. Power Plant Instrumentation and Controls, Philip Kiameh
OE 4201 (A): Instrumentation in Agriculture & Food Industry

Teaching Scheme
Lectures: 3 Hr/Week

Examination Scheme
In Semester: 50 Marks
End Semester: 50 Marks
Credit: 3

Prerequisite: Basics of sensors and transducers, knowledge of Unit operations and basics of process control, PLC and pneumatic and hydraulic instrumentation

Course Objectives:
1. To know the scope of Instrumentation in agriculture field
2. To Know greenhouse, food packaging automation schemes
3. Understand sensors used in agriculture field and weather monitoring stations
4. To get acquainted with food quality standards

Course Outcomes: The student will be able to
1. identify the different unit operations, process control equipments involved in different types of process industries
2. select appropriate measurement techniques for measurement of various process parameters related to soil, greenhouse, Dam and agro-metrology
3. analyze and develop various control loops for processes involved in various food processing plants
4. assess various automation tools to develop automation strategy to Dam, Green house, food processing and packaging in accordance to various food standards

Unit 1: Introduction
Necessity of instrumentation & control for agriculture, engineering properties of soil: fundamental definitions & relationships, index properties of soil, permeability & seepage analysis, shear strength, Mohrs circle of stress, active & passive earth pressures, stability & slopes, Sensors: introduction to sonic anemometers, hygrometers, fine wire thermocouples

Unit 2: Instrumentation in Process industry
Flow diagram of sugar plant & instrumentation set up for it, flow diagram of fermenter & control(batch process), flow diagram of dairy industry & instrumentation set up for it, juice extraction control process & instrumentation set up for it

Unit 3: Instrumentation in Irrigation and Green house System

Unit 4: Instruments in Agriculture
Automation in earth moving equipments & farm equipments, implementation of hydraulic, pneumatic & electronics control circuits in harvesters cotton pickers, tractor etc. classification of pumps: pump characteristics, pump selection & installation. Agrometological instrumentation weather stations, surface flux measurement, soil water content measurement using time-domain reflectometry(TDR).
Unit 5: Food Processing
Definition, Food quality measurement, food safety and standards bill 2005, central committee for food standards, Agmark, Bureau of Indian Standards, Codex Standards, recommended international code of hygiene for various products, Design consideration: cold storage, atmospheric controller and preservatives; biosensors.

Unit 6: Automation in Food Industry
Application of SCADA & PLC in food packing industry, Trends in modern food processing, Equipments for creating and maintaining controlled atmosphere.

Text Books:

Reference books:
OE 4202 (B): Advanced Digital Signal and Image Processing

Teaching Scheme
Lectures: 3 Hr/Week

Examination Scheme
In Semester: 50 Marks
End Semester: 50 Marks
Credit: 3

Prerequisites: Basics of Digital Signal and Digital Image Acquisition

Course Objectives:
1. To study concepts and properties of Multirate DSP.
2. To learn concepts of Adaptive Filters.
3. To learn basic concepts and enhancement techniques of Digital Image.
4. To study various applications of digital image processing in biometrics.

Course Outcomes: The student will be able to
1. suggest the use of Multirate DSP
2. design and implement the adaptive filters.
3. apply concepts of Digital image processing for advanced systems.
4. apply various image enhancement techniques for real-time applications.

Unit 1: Multirate digital signal processing
Basic multirate operation (up sampling, down sampling), Efficient structures for decimation and interpolation, Decimation and interpolation with polyphase filters, Noninteger sampling rate conversion, Efficient multirate filtering Applications.

Unit 2: Stochastic Processes and Spectral estimation

Unit 3: Adaptive filtering

Unit 4: Fundamentals of Digital Image Fundamentals
Digital image representation, fundamental steps in image processing, Elements of digital image processing systems, Image fundamentals: Gray, Colour and Black and white. Color image models: RGB, CMY, HIS, etc models. Various Image Format, Sampling and quantization, Relationship between pixels, Statistical parameters (w.r.t. DIP): Mean, standard deviation, variance, SNR, PSNR etc.

Unit 5: Image Enhancement
Unit 6: Image segmentation and Image Compression

Segmentation: detection of discontinuities, edge linking and boundary detection, thresholding, region-oriented segmentation Representation and description: Representation schemes, descriptors, regional descriptors, pattern and pattern classes, Introduction Classifiers. Introduction to image compression.

Text Books:

Reference Books:
OE 4201 (C): System On Chip

Teaching Scheme
Lectures: 3 Hr/Week

Examination Scheme
In Semester: 50 Marks
End Semester: 50 Marks
Credit: 3

Prerequisite: Basics of MEMS

Course Objective: The students will,
1. study the various microfabrication processes and the materials used for microfabrication.
2. learn characterization of MEMS sensors like pressure and gas
3. understand the concept of micro fluidics and micro reactor

Course Outcome: The student will be able to
1. list and define the various microfabrication processes
2. compare and select the materials for micro fabrication
3. design and develop the engineering stages involved in MEMS sensor and microfluidics
4. characterize the developed MEMS sensor

Unit 1: Microfabrication Process – Lithography
Types of Lithography – photo, e-beam, X-ray; Soft Lithography

Unit 2: Microfabrication Process – Direct write, Pattern transfer
Direct write – focused ion beam, Laser; Pattern transfer – etching types – wet and dry

Unit 3: Material used for Microfabrication
Study of various materials used for micro fabrication – Si, GaAs, Si3N4, SiO2, Au, Pt, Ti; Polymers – PMMA, PTFE, Polyaniline, SU8, Polystyrene, PDMS

Unit 4: Device Engineering I
Pressure sensor, Gas sensor – Design, Material selection, Modelling

Unit 5: Device Engineering II
Study of microfluidics – definition, techniques involved, advantages and applications; Study of micro reactor – definition, types

Unit 6: Characterization
Various principles, tools and methods involved in characterization of MEMS sensors

Text Books:
1. Introduction to Microfabrication by Sami Franssila
2. Foundation of MEMS by Chang Liu 2nd Ed.
3. Fundamentals and Applications of Microfluidics by Nam-Trung Nguyen, Steven T. Wereley 2nd Ed.

Reference Books:
1. Microsystems Design by Stephen D. Senturia
IN 4202: Process Data Analytics Lab

Teaching Scheme
Practical: 2 Hr/week

Examination Scheme
Oral: 50 marks
Credit: 1

Prerequisite: Concepts of Mathematics and Computational techniques

Course Objectives:
1. To explore the statistical analysis techniques for various kinds of data.
2. To understand the concepts and types of Artificial Intelligence and Machine Learning Algorithms.
3. To be familiar with a set of well-known supervised, semi-supervised and unsupervised learning algorithms.

Course Outcomes: The student will be able to
1. apply standard statistical inference procedures to draw conclusions from data analysis.
2. analysis of data using various statistical methods.
3. develop programming logic for various machine learning algorithms.
4. implement various machine learning algorithms to process industries.

List of Experiments: (students are expected to perform any 8 experiments)
1. Introduction to linear and multiple regression function in MATLAB
2. Applying linear & multiple regression to process data from a typical process plant
3. Implement ANOVA for a database
4. Data Analysis using K nearest neighbour Regression
5. Introduction to programming in R
6. Linear regression in R
7. Implementation of Neural Networks for standard data set
8. Implementation of Fuzzy logic for classification of standard data set
9. Implement a classifier for application in field of process industry using data from a standard source
IN 4204: Project Phase II

Teaching Scheme
Tutorial: 2 Hr/Week
Practical: 16 Hr/Week

Examination Scheme
In semester: 100 Marks
Oral: 50 Marks
Credit: 10

Course Outcomes: The student will be able to
1. identify technical problem related to industry, healthcare, society, research organizations.
2. apply the achieved technical knowledge and skills to define the problem statement.
3. identify, design and implement the various stages involved in solving the defined problem statement.
4. test the designed stages to get the desired solution.

The students are expected to work in suitable size groups. The work contribution of each group member should be approaching towards the final solution. The work should be completed in the stipulated time.