

# SAVITRIBAI PHULE PUNE UNIVERSITY

## Syllabus

### B. E. Instrumentation & Control (2019 Course- Credit Based)



Board of Studies  
Instrumentation & Control Engineering  
(w.e.f. June- 2022)

## Savitribai Phule Pune University

### Structure for B. E. Instrumentation and Control - 2019 course (Credit Based)

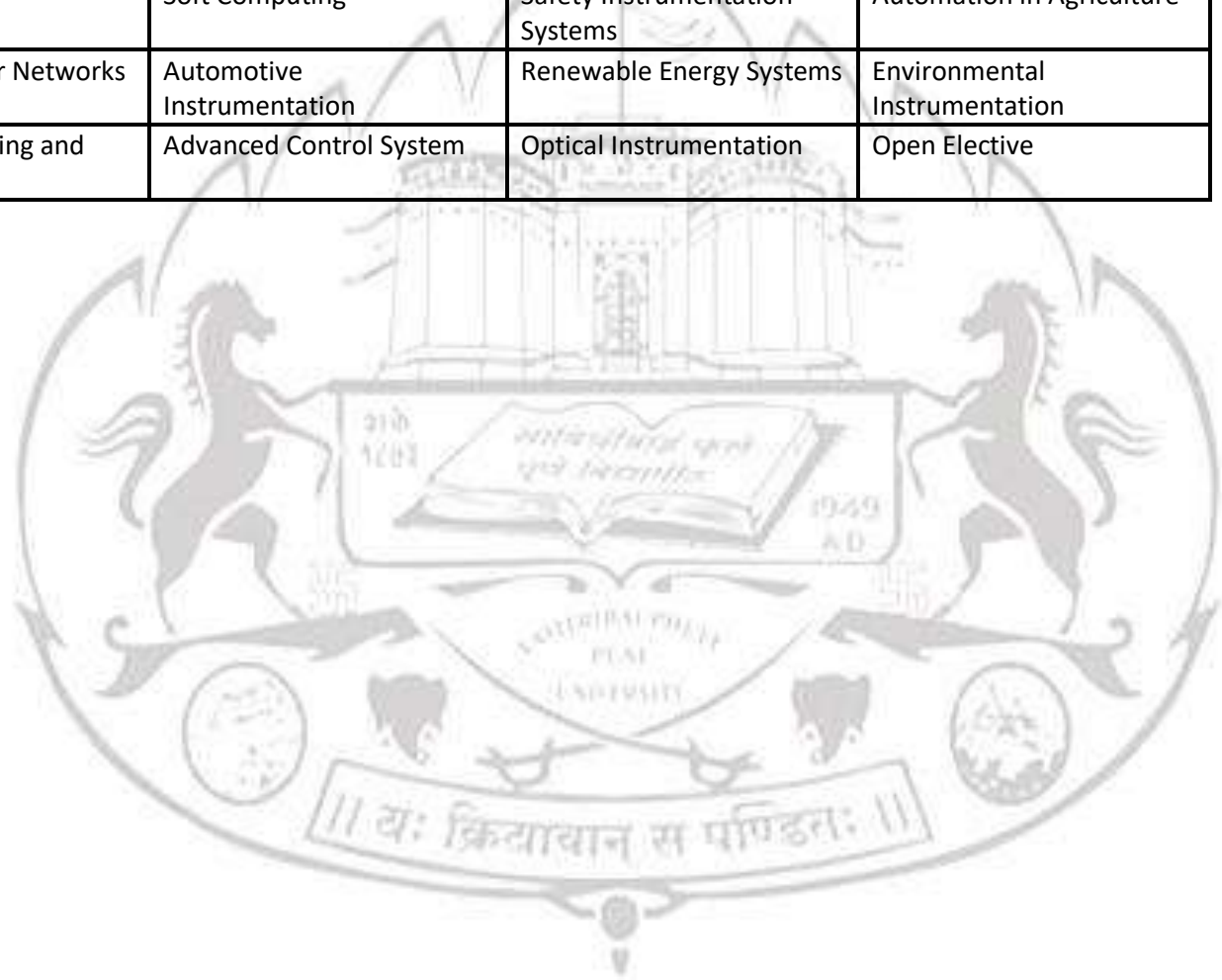
#### SEMESTER- I

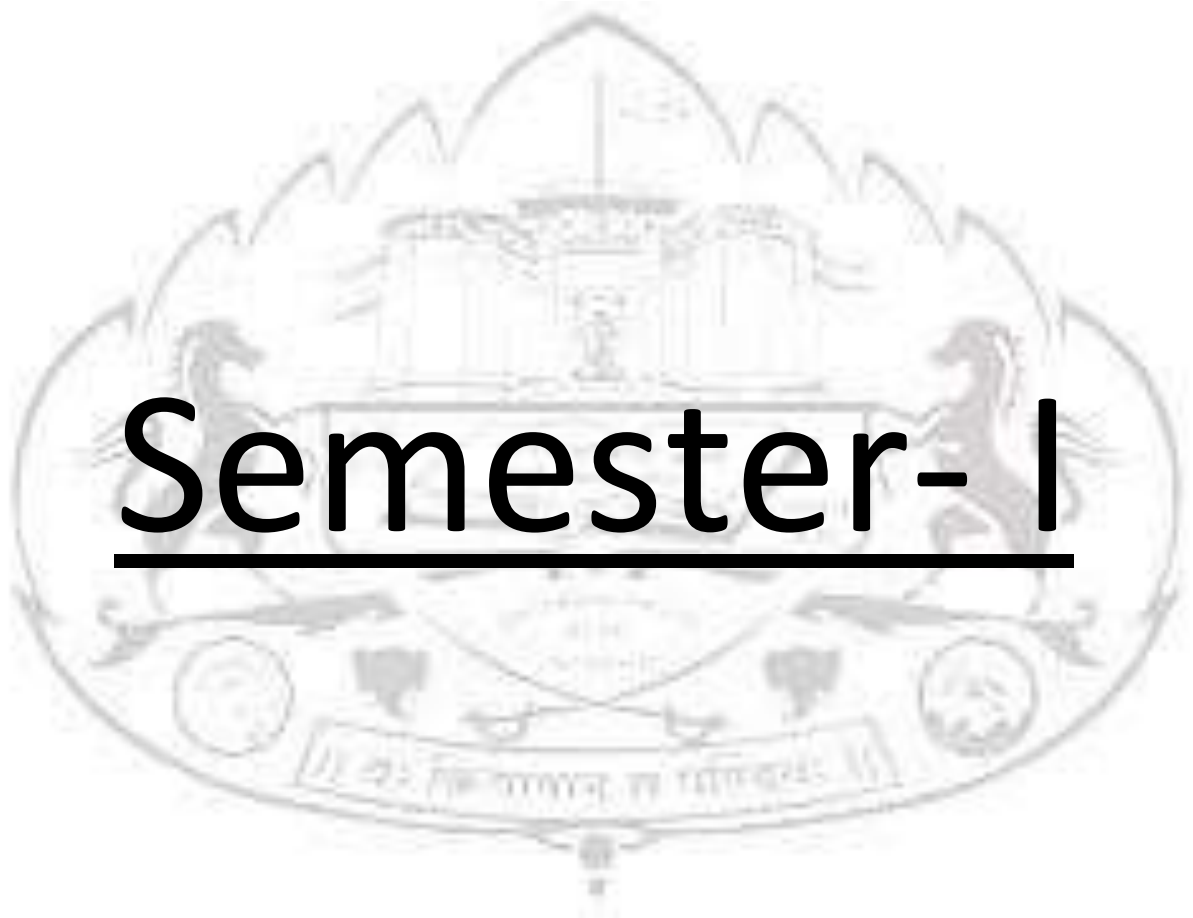
CODE	SUBJECT	TEACHING SCHEME		EXAMINATION SCHEME						Credits	
		TH	PR	Paper		PR	TW	Oral	Total	Theory	PR/OR/TW
				In Semester Assessment	End semester Assessment						
406261	Process Control Techniques	3	2	30	70	50	-	-	150	3	1
406262	Project Engineering and Management	3	2	30	70	-	-	50	150	3	1
406263	Elective- III	3	2	30	70	-	-	50	150	3	1
406264	Elective- IV	3	2	30	70	-	-	50	150	3	1
406265	Virtual Instrumentation Lab	1	2	-	-	-	50	-	50	-	2
406266	Project Stage- I	-	4	-	-	-	50	-	50	-	2
406267	Audit Course- VII	-	-	-	-	-	-	-	-	-	-
<b>Total</b>		<b>13</b>	<b>14</b>	<b>150</b>	<b>350</b>	<b>50</b>	<b>100</b>	<b>150</b>	<b>700</b>	<b>12</b>	<b>8</b>

#### SEMESTER- II

CODE	SUBJECT	TEACHING SCHEME		EXAMINATION SCHEME						Credits	
		TH	PR	Paper		PR	TW	Oral	Total	Theory	PR/OR/TW
				In Semester Assessment	End semester Assessment						
406268	Process Instrumentation	3	2	30	70	-	25	50	175	3	1 (OR+TW)
406269	Advanced Embedded System	3	2	30	70	-	25	50	175	3	1 (OR+TW)
406270	Elective- V	3	-	30	70	-	-	-	100	3	-
406271	Elective- VI	3	-	30	70	-	-	-	100	3	-
406272	Project Stage- II	-	12	-	-	-	100	50	150	-	4 (TW) + 2 (OR) = 6
406273	Audit Course- VIII	-	-	-	-	-	-	-	-	-	-
<b>Total</b>		<b>12</b>	<b>16</b>	<b>120</b>	<b>280</b>	<b>-</b>	<b>150</b>	<b>150</b>	<b>700</b>	<b>12</b>	<b>8</b>

Elective- III (406263)	Elective- IV (406264)	Elective- V (406270)	Elective- VI (406271)
Digital Image Processing	Cloud Computing	Electric Vehicles	Cyber Security
Data Analytics	Soft Computing	Safety Instrumentation Systems	Automation in Agriculture
Wireless Sensor Networks	Automotive Instrumentation	Renewable Energy Systems	Environmental Instrumentation
Process Modelling and Optimization	Advanced Control System	Optical Instrumentation	Open Elective





## 406261: Process Control Techniques

Teaching Scheme:	Examination Scheme:	Credits:
Lectures: 3 Hrs/ Week	Paper: (30+70) 100 Marks	Theory: 3
Practical: 2 Hrs/ Week	In semester Assessment: 30 Marks	Practical: 1
	End Semester Assessment: 70 Marks.	Total: 4 Credits
	Practical: 50 Marks	

**Prerequisites:** Principle and applications of various Sensors and Transducers, Basics of control systems, Principle of actuators and final control element and their applications

**Course Outcomes (COs):** On completion of the course, the students will be able to

1. Estimate the input variables, output variables, constraints and characteristics of processes and determine control objectives.
2. Derive, develop and analysis of a mathematical model using fundamental laws and by performing experiments on prototype systems.
3. Design a PID controller using direct synthesis and IMC strategy for stable processes (either minimum or non-minimum phase). Tuning of PID controller using open loop process reaction curve method and closed loop ultimate cycle method.
4. Design Cascade, Ratio, Feedforward, Selective, Split range and Inferential Control. Understand physical realization limitations due to time delays and RHP zeros.
5. Determine the degree of interaction and proper input-output pairings that best suited for the control problem through the concept of relative gain array (RGA), and design a de-coupler controller

### Unit I: Introduction to Process Control (06)

Introduction to process control, objectives and benefits, Characteristics of processes, Dead time, Single /multi- capacity, self- Regulating /non-self-regulating, Interacting / non-interacting, Linear/nonlinear processes, and selection of control action for them.

### Unit II: Models for Control (07)

Necessity of process modeling, degree of freedom, Mathematical modeling of simple processes like Surge tank level and stirred tank reactor. Development of empirical model using Step and PRBS inputs, Approximation of higher order models, Dynamic behavior of first order and second order systems, Pole- Zero effect on process response.

### Unit III: Feedback Control (07)

Block Diagram, Elements of the feedback Loop, Response to Set- point changes, P, I, D, PI & PID Controller Algorithms, Effect of tuning parameters, Response to Disturbances inputs, Stability Analysis, Ziegler Nichols closed loop tuning, Fine tuning of controllers, Control Performance Measures, Correlations for tuning Constants.

### Unit IV: Advanced Control Techniques (07)

Basic principles, Design Criteria, Performance, Controller Algorithm and Tuning, Implementation issues of- Cascade control, feed forward control, feedback, feed-forward



Control, Ratio control, Selective Control, Split range control and Inferential Control.

### **Unit V: Multivariable Control (07)**

Concept of Multivariable Control: Interactions and its effects, block representation and transfer function matrix of two input two output systems, pairing of controlled and manipulated variables-Relative Gain Array, Singular Value Analysis, effect of Interaction on stability. Decoupler, and decoupler design: ideal decoupler, simplified decoupler and static decoupler.

### **Unit VI: Model based Control (08)**

Model based controller-design procedure for direct synthesis method, tuning relations based on integral error criteria, Smith predictor, Internal Model control-design procedure for FOPDT, SOPDT and Inverse response processes, Effect of model uncertainty and disturbances, design of improved disturbance rejection, IMC based PID controller design procedure for delay free processes and Introduction to Model predictive control.

### **List of Experiments:**

Students are expected to perform minimum eight experiments. (Using MATLAB, SCILAB etc. wherever required.)

1. Obtain an empirical FOPDT/SOPDT model by performing experiment on any given process and validate it.
2. Design and Implementation of Feedback controller for FOPDT /SOPDT Systems
3. Design and Implement Feedback control for Higher Order Processes by reducing it to FOPDT/SOPDT form.
4. Design, Tuning and implementation of Feedback control based on integral error criteria for given process.
5. Design and Implementation of Cascade control loop for a given process.
6. Design and Implementation of Feedforward control for given process.
7. Determine the RGA matrix for given process and select proper pairing of variables
8. Design and Implementation of Model based controller for FOPDT system.
9. Design and Implementation IMC for FOPDT and SOPDT processes.
10. Design and Implementation of IMC based PID controller for delay free systems

### **Text Books:**

1. Process Dynamics and Control- Seborg, Wiley
2. Chemical Process Control: George Stephanopolous, PHI.
3. Process Control: Modeling, Design and Simulation: B. Wayne Bequette, PHI.

### **Reference Books:**

1. Process Control- Designing processes and Control Systems for Dynamic Performance: Thomas E Marlin, McGraw-Hill International.
2. Instrument Engineers' Handbook: Process control: B.G. Liptak, Chilton.
3. Process Control Systems-F.G. Shinskey, TMH.

## 406262: Project Engineering and Management

<b>Teaching Scheme:</b>	<b>Examination Scheme:</b>	<b>Credits:</b>
Lectures: 3 Hrs/ Week	Paper: (30+70) 100 Marks	Theory: 3
Practical: 2 Hrs/ Week	In semester Assessment: 30 Marks	Oral: 1
	End Semester Assessment: 70 Marks.	Total: 4 Credits
	Oral: 50 Marks	

**Prerequisites:** Knowledge of Organization structure, Types & functions.

**Course Outcomes (COs):** On completion of the course, the students will be able to

1. The role and responsibilities in the project organization team
2. The tools of Project Planning and scheduling and planning
3. Plan and prepare the documents/activities required during different phases of the project.
4. The standards need to be used in the project development
5. Interpret the design information from the documents.

### **Unit I: Introduction to Project Management (06)**

Introduction, Definition and objectives of Project Management, Types and classification of projects and related information. Definition of a project, project manager, Project Organizations-Matrix, Project Organizations-Project-Oriented, Selecting an Organization, Project Management Processes, PM as a Leader, Project Organization Chart. number of disciplines involved, interactions and dependencies, effects on costs and project execution time etc. and feasibility analysis of project

### **Unit II: Project Schedule and Time Management (07)**

Introduction and Objectives, What is a WBS? Work Packages, Steps for Creating a WBS, Time Management, Critical Path Method Overview, Types of Diagrams, Activity on Node, Finding Critical Path, Forward Pass Diagram, Backward Pass Diagram, Total Slack, Free Slack, Things that can go wrong, Strategies for Dealing, Tools and Conclusion, review of project process.

### **Unit III: Human Resources, Procurement and Risk Management (08)**

Introduction and Objectives, Project Resource Management, Plan Resource Management, Estimate Activity Resources, Acquire Resources, Develop Team, Manage Team, Control Resources, Project Procurement Management, Project Procurement Plan, Contract Types, Executing Procurement, Risk Management Processes, Types of risk-calculated, Identifying Risks, Developing a Risk Management Plan, Analyse and Prioritize Risks, Develop Risk Responses, and risks which have to be taken, plan B if project fails totally.

### **Unit IV: Instrumentation Preliminary and FEED Project Engineering Documents and Standards (08)**

Introduction to ISA standards: ISA S-5.1, 5.2, 5.3, 5.4, 5.5 and S-20, Preliminary Engineering Documents: PFD, P&ID (ISA S-5.1, 5.3), Process Control Narratives. Front End Engineering and Design (FEED) documents: Plant and piping layouts, Instrument schedule, I/O schedule,

Instrument specification sheets (ISA S-20), logic diagram (ISA S-5.2), sizing and calculation documents, Instrument layout, Junction box layout, system Architecture and network layout diagrams, Control room layouts.

### **Unit V: Detail Engineering Design ( 06)**

Cable Engineering: Class of conductors, Types, Specification, Selection, Cable identification schemes, Cable trays. Earthing and Grounding for General and power Signals. Instrument Loop wiring diagrams (ISA S-5.4), Instrument Hook up, BOM and MBOM. Control room layout, Panel layout and General arrangement (GA) drawings.

### **Unit VI: Construction and Testing Activities ( 07)**

Construction activities: Site conditions and planning, Front availability, Installation and commissioning activities and documents required at this stage. Types of operating Stations, Control system specifications, Control system graphics (ISA S-5.5), databases, I/O allocation, and configuration. Panel testing Procedure and its documentation. Factory Acceptance Test (FAT), Customer Acceptance Test (CAT), Site inspection and testing (SAT), Cold Commissioning and hot commissioning.

### **List of Experiments:**

Students are expected to perform minimum eight experiments.

1. Develop SOW, project specifications and WBS for any instrumentation project.
2. Preparation of Inquiry, Quotation, Comparative statement, Purchase orders.
3. Study of standards and symbols (ANSI / ISA S-5.1).
4. Development of Process & Instrument diagram of typical process.
5. Develop Instrument index sheet for a P&ID developed in experiment 4.
6. Develop specification sheets for transmitters and actuators (ISA S-20 Format).
7. Prepare a loop wiring diagram and Cable schedule.
8. Prepare a Hook up drawings for installation of transmitters and control valve.
9. Develop GA and mimic diagram of a control panel.  
Prepare documents required for FAT of a control panel.

### **Text Books:**

1. Management systems by John Bacon (ISA).
2. Project Management A System Approach to Planning, Scheduling and Controlling by Harold Kerzner (Van Nostrand Reinhold Publishing).
3. Applied instrumentation in process industries by Andrew & Williams (Gulf Publishing).

### **Reference Books:**

1. Process control Instrument Engineers Handbook by Liptak.
2. Instrument Installation Project Management (ISA).
3. Successful Instrumentation & Control Systems Design, by Michael D. Whitt (ISA).
4. Instrumentation Control Systems Documentation, F.A. Meier and C.A. Meier (ISA).





## 406263: Elective- III A) Digital Image Processing

<b>Teaching Scheme:</b>	<b>Examination Scheme:</b>	<b>Credits:</b>
Lectures: 3 Hrs/ Week	Paper: (30+70) 100 Marks	Theory: 3
Practical: 2 Hrs/ Week	In semester Assessment: 30 Marks	Oral: 1
	End Semester Assessment: 70 Marks.	Total: 4 Credits
	Oral: 50 Marks	

**Prerequisites:** Knowledge of Signals and Systems, Digital Signal Processing, z-transform.

**Course Outcomes (COs):** On completion of the course, the students will be able to

1. Explain the different components of image processing system
2. Analyze the different transforms used in image processing
3. Study the image enhancement techniques
4. Describe the process if image analysis
5. Demonstrate the different compression methods in image processing.

### **Unit- I: Fundamentals of Digital Image Processing (06)**

Digital image representation, fundamental steps in image processing, Elements of digital image processing systems, Image fundamentals: Gray, Color 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- II: Image Transforms (07)**

Basic transformations, Perspective transformation, 2-D Transforms: Fourier transform, Discrete cosine transform, short time Fourier transform, Gabor transform, Radon transform, SVD, Wavelet Transforms, Hough Transform, Watershed Transform

### **Unit- III: Image Enhancement (07)**

Enhancement by point processing, spatial filtering, enhancement in the frequency domain. Contrast intensification: linear stretching, non-linear stretching, histogram specification, low contrast stretching. Smoothing: Image averaging, mean filter, order statistics filter, edge preserving smoothing. Sharpening: High pass filtering, homomorphic filtering.

### **Unit- IV : Image Analysis (08)**

**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.

### **Unit- V : Image Compression (08)**

Need, Lossy and lossless compression, Huffman, RLE, LZW, Vector Quantisation, Shift codes, Arithmetic coding, BTC, Transform based compression: JPEG, MPEG, JPEG 2000, etc., properties of image compression schemes.

## Unit- VI: Applications of DIP (06)

Biometrics, Biomedical, Agricultural, Military, Space, etc.

### List of Experiments:

Students are expected to perform minimum eight experiments.

1. Study of various image formats and their handling in Matlab/ Scilab/ Python.
2. Study of statistical properties mean, standard deviation, variance, etc.
3. Histogram specifications.
4. Gray level transformations such as contrast stretching, negative, power law transformation etc.
5. Spatial Domain filtering- smoothing & sharpening filters.
6. Frequency domain filtering, DFT/IDFT of given image.
7. DCT/IDCT of given image.
8. Edge detection using Sobel, Prewitt and Roberts operators.
9. Image Compression Using any method.
10. Case Study Digital Imaging Device.

### Text Books:

1. Gonzalez and Woods, "Digital Image Processing with Matlab", Pearson Education,
2. Madhuri Joshi, "Digital Image Processing", Prentice-Hall International.
3. A. K. Jain, *Fundamentals of Digital Image Processing*, Prentice Hall of India.

### Reference Books:

1. Arthur Weeks Jr., "Fundamentals of Digital Image Processing", Prentice-Hall International.
2. K. R. Castleman, *Digital Image Processing*, Prentice-Hall International.
3. Pratt William, "Digital Image Processing", John Wiley & Sons

## 406263: Elective- III B) Data Analytics

<b>Teaching Scheme:</b>	<b>Examination Scheme:</b>	<b>Credits:</b>
Lectures: 3 Hrs/ Week	Paper: (30+70) 100 Marks	Theory: 3
Practical: 2 Hrs/ Week	In semester Assessment: 30 Marks	Oral: 1
	End Semester Assessment: 70 Marks.	Total: 4 Credits
	Oral: 50 Marks	

**Prerequisites:** Data science, IoT, Data Structures, Machine learning.

**Course Outcomes (COs):** On completion of the course, the students will be able to

1. Describe stages of data life cycle.
2. Use of various statistical techniques for data analysis
3. Find association between variables in data set.
4. Use various algorithm for data classification.
5. Use Various algorithm for big data visualization.
6. Understand use of various advanced tools for data analysis.

### **Unit I: Introduction and Life Cycle (07)**

Introduction: Big data overview, state of the practice in Analytics- BI Vs Data Science, Current Analytical Architecture, drivers of Big Data, Emerging Big Data Ecosystem and new approach.

Data Analytic Life Cycle: Overview, phase 1- Discovery, Phase 2- Data preparation, Phase 3- Model Planning, Phase 4- Model Building, Phase 5- Communicate Results, Phase 6- Operationalize. Case Study: GINA

### **Unit II: Basic Data Analytic Methods (07)**

Statistical Methods for Evaluation- Hypothesis testing, difference of means, wilcoxon rank sum test, type 1 type 2 errors, power and sample size, ANNOVA. Advanced Analytical Theory and Methods: Clustering- Overview, K means- Use cases, Overview of methods, determining number of clusters, diagnostics, reasons to choose and cautions

### **Unit III: Association Rules and Regression (06)**

Advanced Analytical Theory and Methods: Association Rules- Overview, a-priori algorithm, evaluation of candidate rules, case study-transactions in grocery store, validation and testing, diagnostics. Regression- linear, logistics, reasons to choose and cautions, additional regression models.

### **Unit IV: Classification (06)**

Decision trees- Overview, general algorithm, decision tree algorithm, evaluating a decision tree. Naïve Bayes – Bayes" Algorithm, Naïve Bayes" Classifier, smoothing, diagnostics. Diagnostics of classifiers, additional classification methods.

## Unit V: Big Data Visualization (08)

Introduction to Data visualization, Challenges to Big data visualization, Conventional data visualization tools, Techniques for visual data representations, Types of data visualization, Visualizing Big Data, Tools used in data visualization, Analytical techniques used in Big data visualization.

## Unit VI: Advanced Analytics-Technology and Tools (08)

Analytics for unstructured data- Use cases, Map Reduce, Apache Hadoop. The Hadoop Ecosystem- Pig, HIVE, HBase, Mahout, NoSQL. An Analytics Project-Communicating, operationalizing, creating final deliverables.

### List of Experiments:

Students are expected to perform minimum eight experiments.

Data set to be used for practical can be used from following links or any available data set

1. Iris flower dataset," <https://archive.ics.uci.edu/ml/datasets/Iris>".
2. Pima Indians Diabetes Database," <https://www.kaggle.com/datasets/uciml/pima-indians-diabetes-database>"
3. For various technical data sets like battery charging and discharging at different temperature, <https://ti.arc.nasa.gov/tech/dash/groups/pcoe/prognostic-data-repository/>
4. Data set for predictive maintenance  
<https://github.com/nagdevAmruthnath/Predictive-Maintenance>.

### Experiments:

1. Loading of data set in python and splitting it into test and training dataset.
2. Determination of features of data set like numeric, nominal etc.
3. Compute and display summary statistics for each feature available in the dataset. eg. minimum value, maximum value, mean, range, standard deviation, variance and percentiles.
4. Write a program for ANNOVA to find influence of independent variable on dependent variable.
5. Apply suitable clustering algorithm on data to form clusters on key properties of data set.
6. Using data set 4 predict time to failure.
7. Time Series Analysis: Use time series and forecast traffic on a mode of transportation. Sample Test data set available here  
<https://datahack.analyticsvidhya.com/contest/practice-problemtime-series-2/>
8. Twitter Data Analysis: Use Twitter data for sentiment analysis. The dataset is 3MB in size and has 31,962 tweets. Identify the tweets which are hate tweets and which are not. Sample Test data set available here  
<https://datahack.analyticsvidhya.com/contest/practice-problemtwitter-sentiment-analysis/>
9. Bigmart Sales Analysis: For data comprising of transaction records of a sales store. The



data has 8523 rows of 12 variables. **Predict the sales of a store.** Sample Test data set available here <https://datahack.analyticsvidhya.com/contest/practice-problem-big-mart-sales-iii/>

**Text Books:**

1. David Dietrich, Barry Hiller, "Data Science and Big Data Analytics", EMC education services, Wiley publications, 2012, ISBN0-07-120413-X.
2. Ashutosh Nandeshwar , "Tableau Data Visualization Codebook", Packt Publishing, ISBN 978-1-84968-978-6

**Reference Books:**

1. Maheshwari Anil, Rakshit, Acharya, "Data Analytics", McGraw Hill, ISBN:789353160258.
2. Mark Gardner, "Beginning R: The Statistical Programming Language", Wrox Publication, ISBN: 978-1-118-16430-3.
3. Luís Torgo, "Data Mining with R, Learning with Case Studies", CRC Press, Talay and Francis Group, ISBN9781482234893.
4. Carlo Vercellis, "Business Intelligence - Data Mining and Optimization for Decision Making", Wiley Publications, ISBN: 9780470753866.



## 406263: Elective- III C) Wireless Sensor Networks

<b>Teaching Scheme:</b>	<b>Examination Scheme:</b>	<b>Credits:</b>
Lectures: 3 Hrs/ Week	Paper: (30+70) 100 Marks	Theory: 3
Practical: 2 Hrs/ Week	In semester Assessment: 30 Marks	Oral: 1
	End Semester Assessment: 70 Marks.	Total: 4 Credits
	Oral: 50 Marks	

**Prerequisites:** Basic knowledge of Data Communication Networks.

**Course Outcomes (COs):** On completion of the course, the students will be able to

1. Design a wireless sensor network for given sensor data using microcontroller, transceiver, middleware and operating system.
2. Evaluate the performance of schedule based and random Medium Access Control protocols for power consumption, fairness, channel utilization and control packet overhead.
3. Evaluate the performance of Geographic routing protocols for power consumption, scalability and latency parameters.
4. Evaluate the performance of transport control protocols for congestion detection and avoidance, reliability and control packet overhead parameters.
5. Explore and implement solutions to real world problems using sensor devices, enumerating its principles of working.

### **Unit I: Introduction of Wireless Networks (07)**

Background of sensor Wireless Network Technology, Protocol Suites and Standards, OSI Model and TCP/IP Protocol Suite, Adhoc Networks, Comparison of Adhoc and Sensor Networks, Applications of Sensor Networks -Structural Health Monitoring, Traffic Control, Health Care, Pipeline Monitoring, Precision Agriculture, Challenges and Hurdles in Sensor network design.

### **Unit II: Basic Wireless Sensor Technology (08)**

Sensor-node Architecture Hardware components, Energy consumption of sensor nodes, Operating systems and execution environments, Physical layer and transceiver design considerations in Wireless Sensor Networks

**Embedded wireless communication and Protocols:** Wireless Transmission Technology and Systems Bluetooth; IEEE 802.11a/b/g/n series of wireless LANs; ZigBee; Radio-frequency identification (RFID).

### **Unit III: MAC and Routing Protocols (08)**

**Medium Access Control Protocols for Wireless Sensor Networks-** Fundamentals of MAC Protocols, Performance Requirements, and Types of MAC protocols - Schedule-Based and Random Access-Based Protocols, Sensor-MAC, Zebra-MAC.

**Routing Protocols for Wireless Sensor Networks-** Fundamentals of Routing Protocols, Performance Requirements, Routing Strategies in Wireless Sensor Networks - Flooding and its variants, LEACH, Power-Efficient Gathering in Sensor Information Systems, Directed

diffusion, Geographical routing.

#### **Unit IV: Transport Control Protocols for Wireless Sensor Networks (06)**

Traditional Transport Control Protocols-TCP, UDP; Feasibility of Using TCP or UDP for WSNs, Transport Protocol Design Issues, Existing Transport Control Protocols- CODA (Congestion Detection and Avoidance), ESRT (Event-to-Sink Reliable Transport) Performance of Transport Control Protocols.

#### **Unit V: Middleware for Wireless Sensor Networks (06)**

WSN Middleware Principles, Middleware Architecture, Existing Middleware-MiLAN (Middleware Linking Applications and Networks), IrisNet (Internet-Scale Resource Intensive Sensor Networks Services).

#### **Unit VI: Sensor Network Security- Network Security (07)**

Security in Ad Hoc Wireless Networks - Network Security Requirements. Network Security requirements issues and Challenges in security provisioning Network, Security Attacks. Layer wise attack in wireless sensor networks, possible solutions for Jamming, tampering black hole attack, Flooding attack, Key distribution and Management, Secure Routing -SPINS reliability requirements in sensors Networks. Sensor Network Platforms and Tool

#### **List of Experiments:**

Students are expected to perform minimum eight experiments.

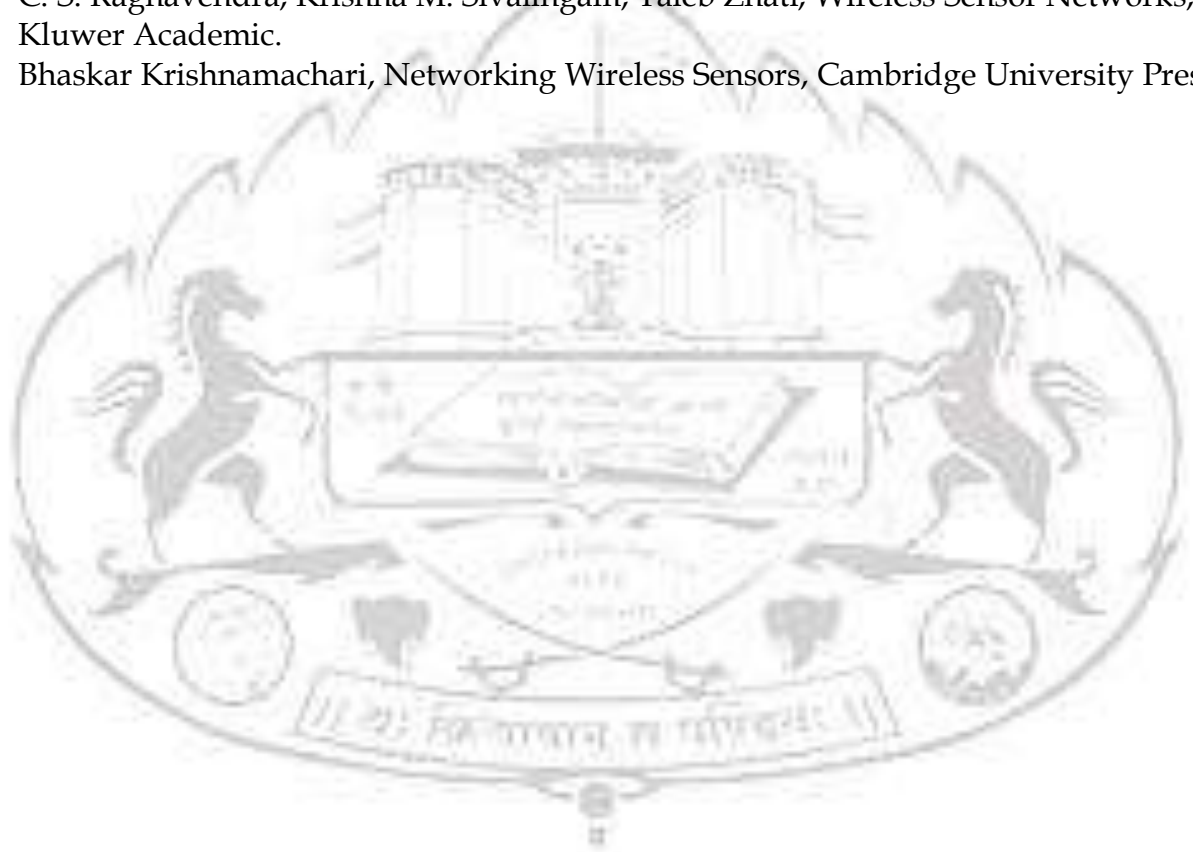
1. To study Hardware Design of Sensor Node
2. To study overview of wireless Sensor networks
3. To study **Routing** Protocols for Wireless Sensor Networks
4. To solve the Numerical problems related to Routing Mechanism
5. To study Fundamentals of **MAC** Protocols
6. To solve the Numerical problems related to Medium Access Control Mechanism
7. To study Wireless data Transmission Technology and Systems
8. To study and solve the Numerical problems related to Zigbee Standard
9. To study Operating Systems for Wireless Sensor Networks
10. To study Transport Control Protocols for Wireless Sensor Networks
11. To solve the Numerical problems related to Transport layer protocols
12. To study Middleware for Wireless Sensor Networks
13. To solve Numerical problems related to Time Sync Numerical problems related to Time Synchronization.
14. Demonstration of WLAN jamming lab

**Text Books:**

1. Kazem Sohraby, Daniel Minoli, Taieb Znati, *Wireless Sensor Networks: Technology, Protocols, and Applications*, John Wiley & Sons.
2. Erdal Çayırıcı , Chunming Rong, “Security in Wireless Ad Hoc and Sensor Networks”, John Wiley and Sons, 2009.

**Reference Books:**

1. Holger Karl, Andreas Willig, *Protocols and Architectures for Wireless Sensor Networks*, John Wiley.
2. Ananthram Swami, Qing Zhao, Yao-Win Hong, Lang Tong, *Wireless Sensor Networks, Signal Processing and Communications Perspectives*, John Wiley.
3. C. S. Raghavendra, Krishna M. Sivalingam, Taieb Znati, *Wireless Sensor Networks*, Kluwer Academic.  
Bhaskar Krishnamachari, *Networking Wireless Sensors*, Cambridge University Press





## 406263: Elective- III D) Process Modelling and Optimization

Teaching Scheme:	Examination Scheme:	Credits:
Lectures: 3 Hrs/ Week	Paper: (30+70) 100 Marks	Theory: 3
Practical: 2 Hrs/ Week	In semester Assessment: 30 Marks	Oral: 1
	End Semester Assessment: 70 Marks.	Total: 4 Credits
	Oral: 50 Marks	

### Unit I: Modeling and Simulations (06)

Introduction, Types of models, modeling of process control systems in time domain and frequency domain, Fitting polynomials in the step test data. Lagrange Interpolation formula, least square fitting.

Fundamental laws: Continuity equations, Energy Equations, Equations of motion, transport Equations, Equations of state, Equilibrium and Chemical Kinetics.

Process models of some typical systems in differential equations form, , dead time, first and second order models, higher order models, Modeling of first and second order electrical systems, mechanical systems, electromechanically systems and oscillatory systems.

### Unit II: Modeling of Mechanical, Chemical systems: (07)

Gravity flow tank, 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 III: Process Identification: (07)

Identification of physical processes, off-line and on-line identification, Step testing, pulse testing, sine wave testing, ATV identification method, prediction error methods, introduction to numerical algorithm for subspace state space identification, Least square method, Relationships among time, Laplace and frequency domain.

### Unit IV: Analysis of multivariable systems. (07)

Open loop and close loop characteristics equations, multivariable Nyquist plot, Loci plot, Niederlinski index, Resiliency, Morari Resiliency Index (MRI), interaction relative gain array (Bristol array) Inverse Nyquist array , robustness Doyle stein criterion, skogestad and morari method .

### Unit V: Basic Concepts of Optimization: (08)

**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 VI: Optimization Techniques: (08)**

**Unconstrained Functions One Dimensional:** Numerical methods for optimizing a function of one variable, scanning and bracketing procedures, Newton, Quasi-Newton and Secant methods, Multidimensional problem, evaluation of unidimensional search methods.

**Unconstrained Multivariable Optimization,** Simplex method, Direct Methods, Indirect Methods, Steepest Descent method.

**Linear Programming :** Basics of Linear Programming, Simplex Algorithm

#### **List of Experiments:**

Students are expected to perform minimum eight experiments.

1. Analysis of first/second order system by using step and ramp input.
1. Simulation of mathematical modeling of electrical/ mechanical system by first principle.
2. Simulation of mathematical modeling of liquid level system.
3. Study of distillation columns.
4. Study of Heat Exchanger.
5. Identification of second order process by prediction error method and compare it with modeling by first principle.
6. Obtaining unknown parameters of second order process by least square technique.
7. Obtaining Relative gain array of any MIMO physical system.
8. Obtaining inverse Nyquist array of any Physical system.
9. Design of optimal control system by using quadratic approximation.
10. Analysis and comparisons of Quasi-Newton and secant methods.
11. Finding optimal solution using Simplex Method system.

#### **Text Books:**

1. W. L. Luyben, Process, Modeling, Simulation and Control for Chemical Engineers • by McGraw Hill, 1973.
2. Thomas Edgar, David Himmelblau, Optimization of Chemical Processes • Second edition, McGraw Hill, 2001.

#### **Reference Books:**

1. W. F. Stoecker, Design of Thermal Systems International Education, McGraw hill 1989.
2. J. Malley, Practical Process Instrumentation and Control • McGraw Hill.
3. Deo Narsingh, System Simulation with digital Computer • Prentice Hall India, New Delhi.
4. Singiresu S.Rao, Engineering Optimization (Theory & Practice), third Edition, New Age International(p) Ltd, Publishers.



## 406264: Elective- IV A) Cloud Computing

<b>Teaching Scheme:</b>	<b>Examination Scheme:</b>	<b>Credits:</b>
Lectures: 3 Hrs/ Week	Paper: (30+70) 100 Marks	Theory: 3
Practical: 2 Hrs/ Week	In semester Assessment: 30 Marks	Oral: 1
	End Semester Assessment: 70 Marks.	Total: 4 Credits
	Oral: 50 Marks	

**Prerequisites:** Networking Fundamentals

**Course Outcomes (COs):** On completion of the course, the students will be able to

1. Understand the cloud computing fundamentals.
2. Explain various data storage and security techniques for cloud
3. Explain virtualization concepts for cloud.
4. Apply cloud concepts to various applications.

### **Unit I: Basics of Cloud Computing (07)**

Overview, Applications, Intranets and the Cloud. Your Organization and Cloud Computing- Benefits, Limitations, Security Concerns.

Software as a Service (SaaS)- Understanding the Multitenant Nature of SaaS Solutions, Understanding SOA.

Platform as a Service (PaaS)-IT Evolution Leading to the Cloud, Benefits of PaaS Solutions, Disadvantages of PaaS Solutions.

Infrastructure as a Service (IaaS)-Understanding IaaS, Improving Performance through Load Balancing, System and Storage Redundancy, Utilizing Cloud-Based NAS Devices, Advantages, Server Types. Identity as a Service (IDaaS).

### **Unit II: Data Storage and Security in Cloud (07)**

Cloud file systems: GFS and HDFS, BigTable, HBase and Dynamo Cloud data stores: Datastore and Simple DB Gautam Shrauf, Cloud Storage-Overview, Cloud Storage Providers. Securing the Cloud- General Security Advantages of Cloud-Based Solutions, Introducing Business Continuity and Disaster Recovery. Disaster Recovery- Understanding the Threats

### **Unit III: Virtualization (07)**

Implementation Levels of Virtualization, Virtualization Structures/Tools and Mechanisms, Types of Hypervisors, Virtualization of CPU, Memory, and I/O Devices, Virtual Clusters and Resource Management, Virtualization for Data-Center Automation. Common Standards: The Open Cloud Consortium, Open Virtualization Format, Standards for Application Developers: Browsers (Ajax), Data (XML, JSON), Solution Stacks (LAMP and LAPP), Syndication (Atom, Atom Publishing Protocol, and RSS), Standards for Security.

### **Unit IV: Amazon Web Services (07)**

Services offered by Amazon Hands-on Amazon, EC2 - Configuring a server, Virtual Amazon Cloud, AWS Storage and Content Delivery Identify key AWS storage options Describe Amazon

EBS Creating an Elastic Block Store Volume Adding an EBS Volume to an Instance Snap  
shooting an EBS Volume and Increasing Performance Create an Amazon S3 bucket and  
manage associated objects. AWS Load Balancing Service Introduction Elastic Load Balancer  
Creating and Verifying Elastic Load Balancer.

### **Unit V: Ubiquitous Clouds and the Internet of Things (07)**

Cloud Trends in Supporting Ubiquitous Computing, Performance of Distributed Systems and  
the Cloud, Enabling Technologies for the Internet of Things (RFID, Sensor Networks and  
ZigBee Technology, GPS), Innovative Applications of the Internet of Things (Smart Buildings  
and Smart Power Grid, Retailing and Supply-Chain Management, Cyber-Physical System),  
Online Social and Professional Networking.

### **Unit VI: Future of Cloud Computing (07)**

How the Cloud Will Change Operating Systems, Location-Aware Applications, Intelligent  
Fabrics, Paints, and More, The Future of Cloud TV, Future of Cloud-Based Smart Devices,  
Faster Time to Market for Software Applications, Home-Based Cloud Computing, Mobile  
Cloud, Autonomic Cloud Engine, Multimedia Cloud, Energy Aware Cloud Computing,  
Jungle Computing. Docker at a Glance: Process Simplification, Broad Support and Adoption,  
Architecture, Getting the Most from Docker, The Docker Workflow.

### **List of Experiments:**

Students are expected to perform minimum eight experiments.

1. Installation and configuration of own Cloud.
2. Implementation of Virtualization in Cloud Computing to Learn Virtualization Basics,  
Benefits of Virtualization in Cloud using Open-Source Operating System.
3. Study and implementation of infrastructure as Service using Open Stack.
4. Write a Program to Create, Manage and groups User accounts in own Cloud by  
installing Administrative Features.
5. Case study on Amazon EC2 to learn about Amazon EC2, Amazon Elastic Compute  
Cloud is a central part of Amazon.com's cloud computing platform, Amazon Web  
Services. How EC2 allows users torrent virtual computers on which to run their own  
computer applications.
6. Case study on Microsoft azure to learn about Microsoft Azure is a cloud computing  
platform and infrastructure, created by Microsoft, for building, deploying and  
managing applications and services through a global network of Microsoft-managed  
data-centers. How it works, different services provided by it.
7. Design and develop custom Application (Mini Project) using Salesforce Cloud.
8. Assignment to install and configure Google App Engine.
9. Design an Assignment to retrieve, verify, and store user credentials using Firebase  
Authentication, the Google App Engine standard environment, and Google Cloud  
Data store.

Creating an Application in SalesForce.com using Apex programming Language.

**Text Books:**

1. Anthony T. Velte Toby J. Velte, Robert Elsenpeter, "Cloud Computing: A Practical Approach", 2010, The McGraw-Hill.
2. Dr. Kris Jamsa, " Cloud Computing: SaaS, PaaS, IaaS, Virtualization and more" , Wiley Publications, ISBN: 978-0-470-97389-9.
3. Gautam Shrof, "ENTERPRISE CLOUD COMPUTING Technology Architecture, Applications, Cambridge University Press, ISBN: 9780511778476

**Reference Books:**

1. Dr. Kumar Saurabh,"Cloud Computing", Wiley Publication, ISBN10: 8126536039
2. Buyya, "Mastering Cloud Computing", Tata McGraw Hill, ISBN-13: 978-1-25-902995-0,
3. Barrie Sosinsky,"Cloud Computing", Wiley India, ISBN: 978-0-470-90356-8
4. Kailash Jayaswal, "Cloud computing", Black Book, Dreamtech Press
5. Thomas Erl, Zaigham Mahmood and Ricardo Puttini, "Cloud Computing: Concepts,Technology and Architecture", Pearson, 1st Edition, ISBN :978 9332535923,
6. Tim Mather, Subra K, Shahid L.,Cloud Security and Privacy, Oreilly, ISBN-13 978-81-8404-815-5





## 406264: Elective- IV B) Soft Computing

<b>Teaching Scheme:</b>	<b>Examination Scheme:</b>	<b>Credits:</b>
Lectures: 3 Hrs/ Week	Paper: (30+70) 100 Marks	Theory: 3
Practical: 2 Hrs/ Week	In semester Assessment: 30 Marks	Oral: 1
	End Semester Assessment: 70 Marks.	Total: 4 Credits
	Oral: 50 Marks	

**Prerequisites:** Controllers basics and Process.

**Course Outcomes (COs):** On completion of the course, the students will be able to

1. Identify and describe different auto-tuning controller techniques their roles in building intelligent controls.
2. Recognize the feasibility of applying a soft computing methodology for a particular problem.
3. Apply fuzzy logic and reasoning to handle uncertainty and solve engineering control problems.
4. Apply neural networks to pattern classification and regression problems.
5. Evaluate and compare solutions by various soft computing approaches for a given problem.

### **Unit I: Neural Networks-1 (Introduction & Architecture) (08)**

Neuron, Nerve structure and synapse, Artificial Neuron and its model, activation functions, Neural network architecture: single layer and multilayer feed forward networks, recurrent networks. Various learning techniques; perception and convergence rule, Auto-associative and hetro-associative memory.

### **Unit II: Neural Networks-II (Back Propagation Networks) (06)**

Architecture: perceptron model, solution, single layer artificial neural network, multilayer perception model; back propagation learning methods, effect of learning rule co-efficient, back propagation algorithm, factors affecting backpropagation training, applications, ADALINE algorithm.

### **Unit III: Fuzzy Logic-I (Introduction) (08)**

Basic concepts of fuzzy logic, Fuzzy sets and Crisp sets, Fuzzy set theory and operations, Properties of fuzzy sets, Fuzzy and Crisp relations, Fuzzy to Crisp conversion.

### **Unit IV: Fuzzy Logic -II (Fuzzy Membership, Rules) (06)**

Membership functions, interference in fuzzy logic, fuzzy if-then rules, Fuzzy implications, and Fuzzy algorithms, Fuzzyfication & Defuzzification, Fuzzy Controller, Industrial applications.

### **Unit V: Fuzzy Logic Based Control (06)**

Fuzzy Controllers: Preliminaries - Fuzzy sets in commercial products - basic construction of fuzzy controller - Analysis of static properties of fuzzy controller - Analysis of dynamic

properties of fuzzy controller - simulation studies -case studies - fuzzy control for smart cars.

### **Unit VI: Neuro - Fuzzy and Fuzzy - Neural Controllers (08)**

Neuro - fuzzy systems: A unified approximate reasoning approach - Construction of rule bases by self-learning: System structure and learning algorithm - A hybrid neural network based Fuzzy controller with self-learning teacher. Fuzzified CMAC and RBF network based self-learning controllers.

#### **List of Experiments:**

Students are expected to perform minimum eight experiments.

1. Learning rules and activation functions in NN
2. Development of logic using MP and Hebb neuron model
3. Development of supervised learning using NN Toolbox
4. Development and testing of perceptron NN algorithm
5. Development of ADALINE algorithm with bipolar inputs and outputs
6. Development of auto associative network using outer product rule
7. Development of fuzzy membership functions and fuzzy set properties
8. Development of logic for fuzzy relations
9. Verification of logic using fuzzy relations
10. Design of a fuzzy controller systems using fuzzy tool of Matlab
11. Application development using NN/Fuzzy logic

#### **Text Books:**

1. S. Rajsekaran & G.A. Vijayalakshmi Pai, "Neural Networks, Fuzzy Logic and Genetic Algorithm: Synthesis and Applications" Prentice Hall of India.
2. Timothy J. Ross, "Fuzzy Logic with Engineering Applications" Wiley India.
3. Kosco B, Neural Networks and Fuzzy Systems: A Dynamic Approach to Machine Intelligence, Prentice Hall of India, New Delhi, 1992.
4. Jacek M. Zurada, Introduction to Artificial Neural Systems -, Jaico Publishing House, 1997.  
Klir G.J and Folger T.A, Fuzzy sets, Uncertainty and Information, Prentice Hall of India, New Delhi 1994.

#### **Reference Books:**

1. N.P. Padhy, "Artificial Intelligence and Intelligent Systems", Oxford University Press.
2. Kumar Satish, "Neural Networks" Tata Mc-Graw Hill
3. Bose and Liang, Artificial Neural Networks, Tata Mc-Graw Hill, 1996.  
Simon Haykin, Neural Networks, ISA, Research Triangle Park, 1995.

## 406264: Elective- IV C) Automotive Instrumentation

Teaching Scheme:	Examination Scheme:	Credits:
Lectures: 3 Hrs/ Week	Paper: (30+70) 100 Marks	Theory: 3
Practical: 2 Hrs/ Week	In semester Assessment: 30 Marks	Oral: 1
	End Semester Assessment: 70 Marks.	Total: 4 Credits
	Oral: 50 Marks	

**Prerequisites:** The students should be conversant with sensors, transducers, measurement techniques, batteries and IoT

**Course Outcomes (COs):** On completion of the course, the students will be able to

1. Design and implement measurements system in automobiles using various sensors and transducers.
2. Develop automated systems for safety of passengers and vehicles.
3. Implement different standards and protocols for automobile automation.
4. Identify designing required for electric vehicle charging.
5. Design and develop IoT automation for vehicle manoeuvrability and accident avoidance.

### Unit I: Introduction to Vehicle Experimental Techniques (07)

Characteristics of sensors for pressure, temperature, flow, speed, displacement, viscosity, torque, vibration, oil, air and gas density. Engine measurement units and equations for torque, horse power, displacement, compression, speed Data acquisition systems (DAQ) for vehicle parameters. Test procedures, recording experimental data, and analyzing test results for noise measurements, vibration measurements, determination of fuel consumption, endurance tests to determine durability, vehicle dynamics tests, dynamometers (roller test benches).

### Unit II: Mechanical Measurement (08)

Introduction to measurements - Construction, principle, working of Instruments for measuring force, torque, pressure, temperature, fluid flow, velocity, rotational speed, vibrations. Measurement of vehicle performance parameters - Fuel Economy, Acceleration, Speed, Ride Comfort, Handling Characteristics.

### Unit III: Advanced Safety System (06)

Active and passive safety system - Active safety features that are like lane departure alert, automatic high beams, the pre-collision system, brake assist, and dynamic radar cruise control. Passive safety features airbags, crumple zones, and seatbelts with pretensioners

### Unit IV: Automotive Standards and Protocols (07)

IVN protocols in the automotive industry, including Controller Area Network (CAN), Controller Area Network Flexible Data-Rate (CAN FD), Media Oriented Systems Transport (MOST), FlexRay, and Local Interconnect Network (LIN), Indian Standards (IS) and Automotive Industry standards (AIS). EV charging industry standards and protocols

### **Unit V: Electric Vehicle Requirements and Design (08)**

Basics of electromobility, motors, chassis, battery charging. Electrical motor topologies and operations principles: radial, axial, transversal flux motors and power trains.

Specification of the electrical vehicle in concordance with driving cycle and range requirements.

Critical Aspects of Design for Electric Vehicles - DC Converters, Inverters, Battery Equalizers, Generator (onboard chargers), Power Electronic Controllers, Thermal Systems

Infrastructure required for electrical vehicles including charging stations, wireless charging, maintenance and repair.

### **Unit VI: IoT in Automobile (06)**

Vehicle to vehicle (V2V), Vehicle to infrastructure (V2I), Vehicle to pedestrians (V2P), Vehicle to network (V2N), In-vehicle Infotainment and Telematics, Automotive Maintenance System.

#### **List of Experiments:**

Students are expected to perform minimum eight experiments.

1. Measurement and analysis of noises in vehicles
2. Measurement and analysis of vibrations in vehicles
3. Measurement of vehicle performance parameter – Fuel Economy
4. Study of sensor interface and DAQ in Electronic Control Unit (ECU)
5. Study of pre-collision system in vehicles
6. Study of power trains in electric vehicles
7. Study and implementation of Controller Area Network (CAN) in ECU
8. Design of wireless charging and Vehicle to vehicle (V2V) charging for Electric vehicles
9. Study of Vehicle to pedestrians (V2P) communications for safety
10. Design of Battery Equalizers for electric vehicles
11. Study of specification of the electrical vehicle for driving cycle and range requirements
12. Study of Indian Standards (IS) and Automotive Industry standards (AIS).

#### **Text Books:**

1. Automotive Electrics and Instrumentation by Sheeba Rani, SubhaHency Jose, P. Rajalakshmy, Educreation Publishing, 2019.
2. Understanding Automotive Electronics by William Ribbens, Butterworth-Heinemann, 8th Edition, 2017.
3. Determination of Automobile Performance, Faulkner Fred L, BiblioLife.
4. Electric Vehicle Engineering by Per Enge, Nick Enge, Stephen Zoepf, McGraw Hill Professional, 2021.

#### **Reference Books:**

1. Integrated Automotive Safety Handbook, Seiffert Ulrich W., SAE International.
2. Automotive Technology: Principles, Diagnosis, and Service, Pearson; 6th edition, 2021.
3. Electric Vehicle Technology Explained, by John Lowry, James Larminie, Wiley; 2nd edition, 2012.
4. Connected Vehicles in the Internet of Things by Zaigham Mahmood, Springer Cham, 2020



## 406264: Elective- IV D) Advanced Control Systems

<b>Teaching Scheme:</b>	<b>Examination Scheme:</b>	<b>Credits:</b>
Lectures: 3 Hrs/ Week	Paper: (30+70) 100 Marks	Theory: 3
Practical: 2 Hrs/ Week	In semester Assessment: 30 Marks	Oral: 1
	End Semester Assessment: 70 Marks.	Total: 4 Credits
	Oral: 50 Marks	

**Prerequisites:** Control Systems, Modern Control Theory, z transform, matrices

**Course Outcomes (COs):** On completion of the course, the students will be able to

1. Compute pulse transfer and time response of digital control systems.
2. Realize pulse transfer function and investigate stability of digital control systems using pole locations, Jury stability test, bilinear transformation and Routh stability test.
3. Compute state model from pulse transfer function, pulse transfer function from state model and state transition matrix of digital control systems.
4. Investigate state controllability, state observability and design state regulator, full order state observer and optimal state regulator for digital control systems.
5. Investigate stability of continuous and discrete time LTI systems represented in state space using Lyapunov method.
6. Analyze non-linear systems using describing function and phase plane method.

### **Unit I: Introduction to Digital Control Systems (07)**

Functional and analytical block diagrams of digital (sampled data) control system, sampling and reconstruction, data conversion and quantization, zero order hold and its transfer function, pulse transfer function, computation of pulse transfer function, systems with zero order hold and computation of their pulse transfer function, impulse response and step response

### **Unit II: Realization and Stability of Digital Control Systems (07)**

Realization of pulse transfer function: direct realization, cascade realization and parallel realization, mapping between s and z plane, stability of digital control systems from pole locations, Jury stability test, bilinear transformation and Routh stability test

### **Unit III: State Space Representation of Digital Control Systems (08)**

State space representation of digital control systems represented by pulse transfer function (controllable canonical, observable canonical forms, diagonal/Jordan canonical form), conversion of state model into pulse transfer function, solution of homogeneous and non-homogeneous state equations of digital control systems, state transition matrix of digital control systems, its properties, computation by z transform method, Caley Hamilton theorem method

### **Unit IV: Design of Digital Control Systems in State Space (07)**

Concept of state controllability and state observability, investigation of state controllability



and state observability using Kalman and Gilbert tests, design of state regulator via pole placement (all three methods), design of full order state observer, design of dynamic and steady state optimal state regulator for quadratic performance index

#### **Unit V: Stability Analysis of Continuous and Discrete Time LTI systems using Lyapunov Stability (06)**

Positive definiteness, positive semi-definiteness, negative definiteness, negative semi-definiteness and indefiniteness of quadratic function, Sylvester criterion, stability in the sense of Lyapunov, asymptotic stability, Lyapunov's direct and second method for stability analysis of Continuous and Discrete Time LTI systems

#### **Unit VI: Non-linear Systems and their Stability Analysis (07)**

Peculiar characteristics of non-linear systems, common non-linearities (inherent and intentional), describing function, describing function of ideal relay and saturation, stability analysis using describing function, phase plane analysis, singular points and their types, phase trajectory and phase portrait, construction of phase trajectory using isocline method

#### **List of Experiments:**

Students are expected to perform minimum eight experiments.

1. Software simulation for determining step response of digital control systems
2. Software simulation for comparative study of effect of sampling period on the stability of digital control systems
3. Develop software program to compute state model of digital control system
4. Develop software program to compute state transition matrix of digital control system by software program
5. Develop software program to investigate state controllability and state observability
6. Develop software program to design state regulator using pole placement approach
7. Develop software program to design of optimal state regulator for quadratic performance index
8. Develop software programs to investigate stability of continuous and discrete time LTI systems using Lyapunov method
9. Investigate stability using describing function
10. Construct phase trajectory using isocline method

#### **Text Books:**

1. Gopal. M., "Digital Control and State Variable Methods", 2<sup>nd</sup> Ed., Tata McGrahill Publication, New Delhi, 2003.
2. K. Ogata, "Discrete-Time Control Systems", 2<sup>nd</sup> Ed., Prentice Hall India, New Delhi, 2005
3. M. Vidyasagar, "Nonlinear Systems Analysis", 2<sup>nd</sup> Ed., Prentice Hall, 1993.

#### **Reference Books:**

1. B. C. Kuo, "Digital Control Systems", 2<sup>nd</sup> Ed., Oxford University Press, 2012.
2. Graham C., Goodwill, S. F. Graebe and M. E. Salgado, "Control System Design" Pearson; US edition (2000).

## 406265: Virtual Instrumentation Lab

### Teaching Scheme:

Lectures: 1 Hr/ Week

Practical: 2 Hrs/ Week

### Examination Scheme:

Term Work: 50 Marks

### Credits:

TW: 2

Total: 2 Credits

**Course Outcomes (COs):** On completion of the course, the students will be able to

1. Understanding Virtual Instrument concepts.
2. Develop program for specific application using Virtual Instrument software.
3. To acquire, analyze and display the throughput of any compatible system.
4. Interface hardware and software using Virtual Instrument.

Virtual Instrumentation: Historical perspective - advantages - block diagram and architecture of a virtual instrument - Conventional Instruments versus Traditional Instruments - data-flow techniques, graphical programming in data flow, comparison with conventional programming. VI Programming Techniques, Help and Resources for VI. VIs and sub-VIs, loops and charts, arrays, clusters and graphs, case and sequence structures, formula nodes, local and global variables, String and file I/O. Data Acquisition in VI- Input/Output Operation Instrument Drivers, Publishing measurement data in the web.

### List of Experiments

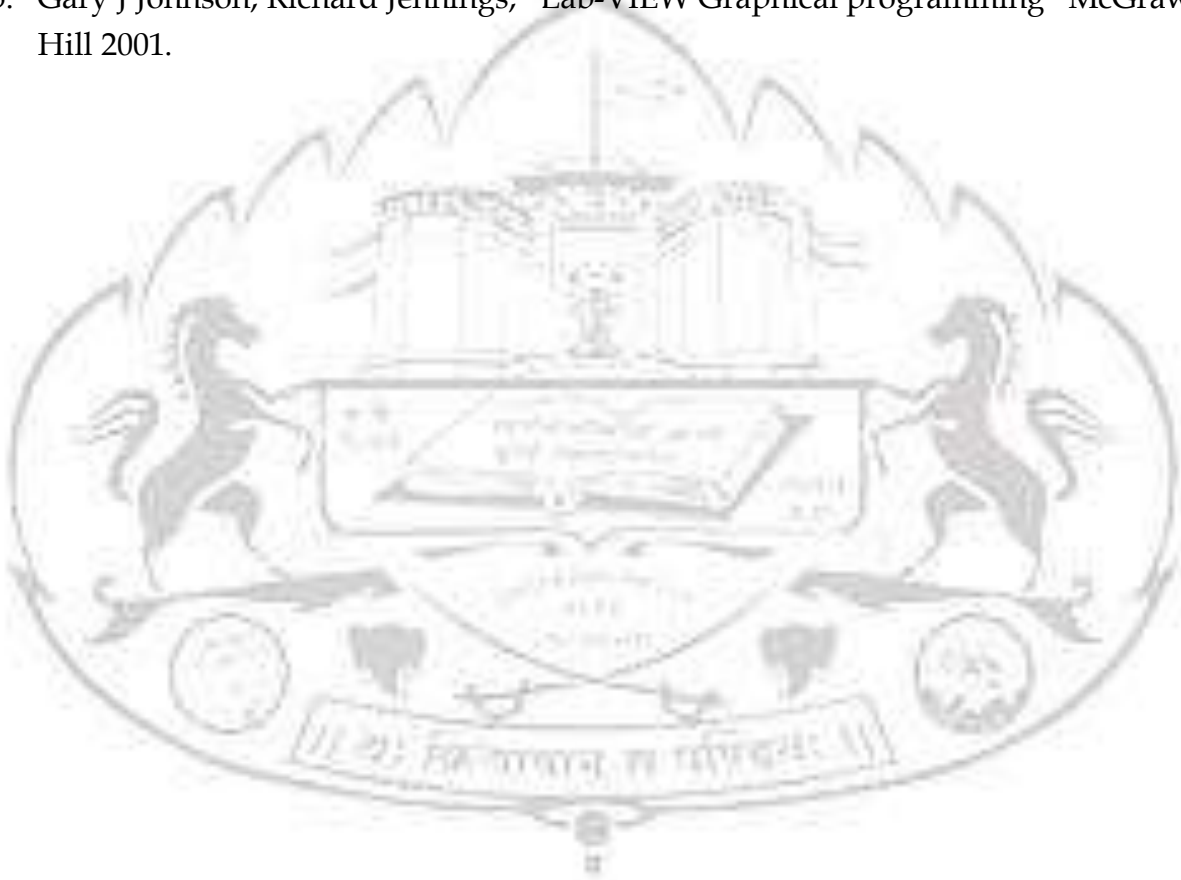
Students are expected to perform minimum eight experiments. These experiments can be performed using tools like LabVIEW, MATLAB/ Simulink, IOT and Cloud based VI etc.

1. Introduction to VI, Basic Operations, Controls, Indicators and Structures.
2. To perform basic Arithmetic Operations using VI.
3. To perform Boolean operations using VI.
4. Preparing simple VIs (learning front panel and block diagram environment).
5. To perform convolution of two signals using VI.
6. To apply filtering technique for a given input signal.
7. Generate signals such as Sine, Square, and Triangular using VI.
8. Developing simulation examples using the VI.
9. Simulation of PID Controller using VI.
10. Developing VI using signal processing toolkit.
11. Developing VI using Control system toolkit.
12. Developing VI using DSP toolkit.
13. Hardware-Software interfacing using VI.
14. Developing Web based application using VIs.
15. Creating Sub VIs and Its usage in High Level Applications

## 16. Data Acquisition in VI

### Text and Reference Books

1. Robert H Bishop "Learning with LabVIEWs" Prentice Hall,2003
2. Kevin James, PC Interfacing and Data Acquisition: Techniques for Measurement, Instrumentation and Control, Newnes, 2000.
3. Rick Bitter, LabVIEW advanced programming technique, 2nd Edition, CRC Press, 2005
4. Jovitha Jerome, Virtual Instrumentation using LabVIEW, 1st Edition, PHI, 2001.
5. Gary J Johnson, Richard Jennings, "Lab-VIEW Graphical programming" McGraw Hill 2001.



### 406266- Project Stage- I

**Teaching Scheme:**

Practical: 4 Hrs/ Week

**Examination Scheme:**

Term Work: 50 Marks

**Credits:**

TW: 2

Total: 2 Credits

### Guidelines for Project Stage- I

1. Term work assessment is based on the project topic. It consists of Literature Survey and basic project work. The abstract of the project should be submitted before Term work assessment.
2. The report consists of the Literature Survey, basic project work and the methodology.
3. The examination is conducted by two examiners. The head of the department should constitute the committee of senior faculty members from the department/ institute for this viva examination. The examiners appointed must have minimum 2 years with PG qualification.
4. The assessment is based on Innovative Idea, Depth of understanding, Applications, Individual contributions, presentation, and the grade given by the internal guide based on the work carried out in a semester.
5. A log book of Work carried out during the semester will be maintained with monthly review remarks by the guide and HoD.
6. A certified copy of report is required to be presented to external examiner at the time of final examination.

## 406267: Audit Course- VII

In addition to credits course, it is recommended that there should be audit course (non-credit course) preferably in each semester from second year. The student will be awarded grade as AP on successful completion of audit course. The student must opt for one of the audit courses per semester, starting in second year first semester. Such audit courses can help the student to get awareness of different issues which make impact on human lives and enhance their skill sets to improve their employability. List of audit courses offered in each semester is provided in curriculum. Each student must choose one audit course from the list per semester. Evaluation of audit course will be done at institute level. Method of conduction and method of assessment for audit courses is suggested.

The student registered for audit course shall be awarded the grade AP and shall be included such grade in the Semester grade report for that course, provided student has the minimum attendance as prescribed by the Savitribai Phule Pune University and satisfactory in-semester performance and secured a passing grade in that audit course. No grade points are associated with this 'AP' grade and performance in these courses is not accounted in the calculation of the performance indices SGPA and CGPA. Evaluation of audit course will be done at institute level itself.

(Ref-[http://www.unipune.ac.in/Syllabi\\_PDF/revised-2015/engineering/UG\\_RULE\\_REGULATIONS\\_FOR\\_CREDIT\\_SYSTEM-2015\\_18June.pdf](http://www.unipune.ac.in/Syllabi_PDF/revised-2015/engineering/UG_RULE_REGULATIONS_FOR_CREDIT_SYSTEM-2015_18June.pdf))

### **Guidelines for Conduction (Any one or more of following but not limited to)**

- Lectures/ Guest Lectures
- Visits (Social/Field) and reports
- Demonstrations
- Surveys
- Mini Project
- Hands on experience on specific focused topic
- Any relevant courses from NPTEL/ SWAYAM/ MOOCs/ ARPIT etc.

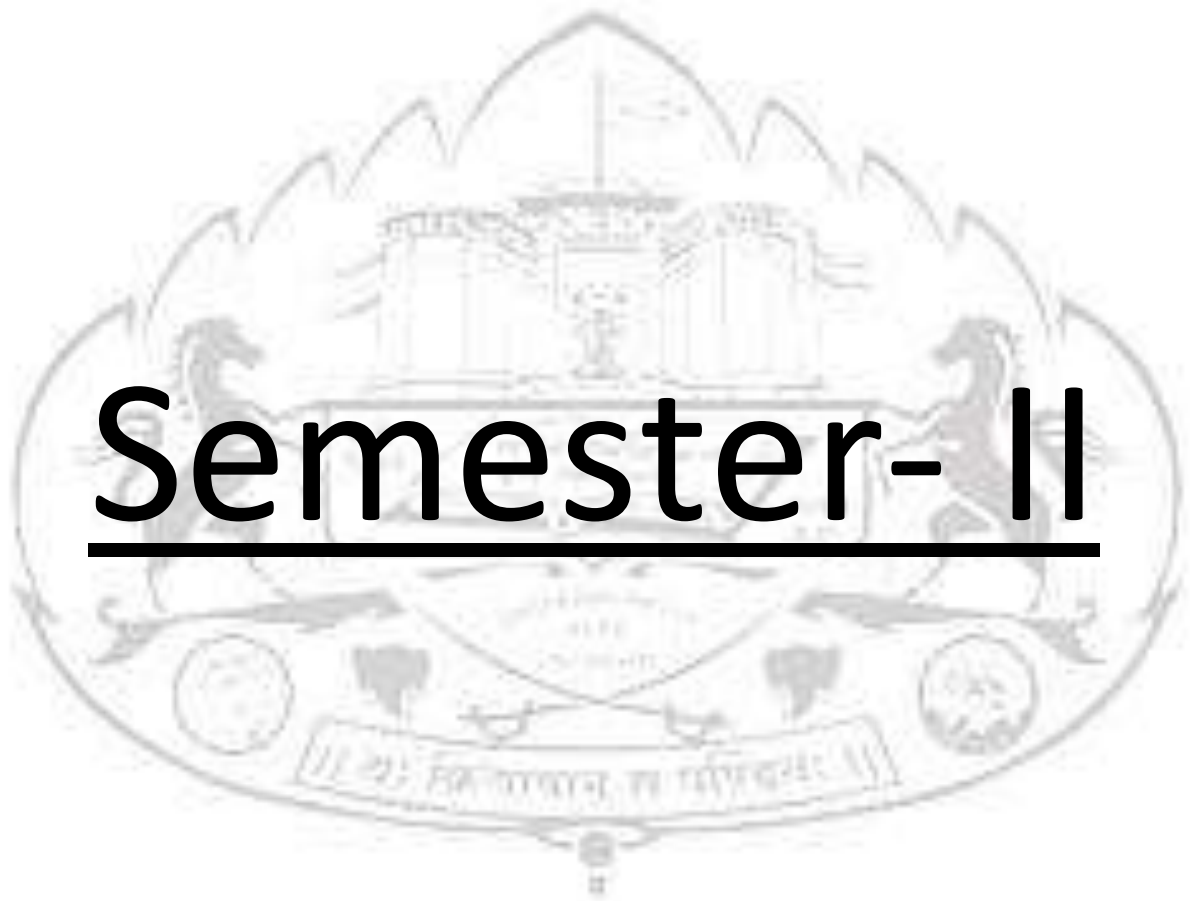
### **Guidelines for Assessment (Any one or more of following but not limited to)**

- Written Test
- Demonstrations/ Practical Test
- Presentations
- IPR/Publication
- Report
- Assignments from NPTEL/ SWAYAM/ MOOCs/ ARPIT etc.

### **Audit courses suggested by BoS, Instrumentation Engineering:**

1. National Education Policy- 2020
2. Latex for Engineers
3. Constitution of India





# Semester- II

## 406268: Process Instrumentation

Teaching Scheme:	Examination Scheme:	Credits:
Lectures: 3 Hrs/ Week	Paper: (30+70) 100 Marks	Theory: 3
Practical: 2 Hrs/ Week	In semester Assessment: 30 Marks	Oral+TW: 1
	End Semester Assessment: 70 Marks.	Total: 4 Credits
	Oral: 50 Marks	
	Term Work: 25 Marks	

**Prerequisites:** Principle of different controllers and their applications, Principle of various unit operations & unit processes.

**Course Outcomes (COs):** On completion of the course, the students will be able to

1. Discuss the basic operations of Heat Exchanger, Dryer, Evaporator, Boiler, Distillation column, Reactors, Pumps and Compressors and Determine the scaling equations for unit processes and operations.
2. Analyze dynamics of of Heat Exchanger, Dryer, Evaporator, Boiler, Distillation column, Reactors, Pumps and Compressors. Identify process variables, control variables and an appropriate manipulated variables for their control and disturbance variables.
3. Design an appropriate regulatory and servo controller (Feedback, Cascade and Feed forward) for Heat Exchanger, Dryer, Evaporator, Distillation column and Reactor to achieve desired performance.
4. Design an appropriate regulatory and servo controller (Feedback, Cascade, Selective Split range, Anti-surge) for Boiler, Pumps and Compressors to achieve desired performance.
5. Design/Develop, tuning, implementation and simulation of appropriate servo and regulatory controller for a given process using MATLAB Simulink and Estimate the performance measures. (Rise time, Settling time, Overshoot, Integral errors)

### Unit I: Heat Exchanger (07)

Operation of heat exchanger, controlled and manipulated variables in the heat exchanger control, Degrees of freedom analysis, Gain, and Time Constant, Dead Time and Tuning, Feedback, feed-forward, feedback-Feed forward control and cascade control strategies for Liquid-to-Liquid Heat Exchanger, Steam Heater and Condenser Control, Scaling: types of scaling, scaling of heat exchanger

### Unit II: Boiler Controls (07)

Operation of boiler, control variables manipulated variables and disturbance variables in boiler control, boiler dynamics, safety interlocks and burner management system, Boiler-Pressure and Firing Rate Controls, Feedforward Control-Load Demand and stability, Fuel Controls, Air to fuel ratio controls, Boiler drum level control, Steam temperature control, Boiler blow down, Optimization of boilers and Strategy for excess air optimization.

### **Unit III: Distillation Controls (07)**

Operation of distillation column process variables, control variables manipulated variables and disturbance variables in distillation column control, Degree of freedom analysis, Feedback, Cascade and Inferential control strategies for flow control of distillate, top and bottom composition control, reflux ratio control, pressure control, level of column, level of accumulator. Multivariable control, Scaling of Distillation Column

### **Unit IV: Dryer Controls and Evaporator (08)**

Types and operation of dryers, objectives, characteristics, process variables, control variables manipulated variables and disturbance variables in dryers, Feedback, Cascade and Inferential control of various types of dryers.

Types and operation of evaporators, process variables, control variables manipulated variables and disturbance variables in evaporators, Feedback, Cascade, Feed-forward and Selective control strategies for evaporators.

### **Unit V: Chemical Reactor Controls (07)**

Types of reactions and reactors, factors governing the conduct of reaction, stability of reactors, time constant, effects of lag, flow control, temperature control, pH control, end point detection of continuous and batch reactors. Sequential & logic control in batch process, batch production management.

### **Unit VI: Pumps and Compressors Controls (06)**

**Pumps:** Types, On-off level, flow and pressure Control, Multi-pump system control, Starting and Stopping of pumps.

**Compressors:** Types, On-off Controls, Surge phenomenon, anti-surge control, throttling and override control.

#### **List of Experiments:**

Students are expected to perform minimum eight experiments on above topics. OR (Using DCS, MATLAB, SCILAB etc. wherever required.)

1. Design and implementation of controller for heat exchanger.
2. Develop and Implement PLC program for safety interlocks of boiler
3. Design and implementation of controller for steam drum level control
4. Design and implementation of controller for surge vessel level control.
5. Design and implementation of controller for distillation column control
6. Develop cascade controller for evaporator/dryer
7. Design and implementation of controller for chemical reactor
8. Develop anti-surge control strategy for compressor controls
9. Develop feedback control strategy of pumps
10. Process Control Instrumentation - A case study on any plant.

#### **Text Books:**

1. Instrument Engineers' Handbook: Process Control: B.G. Liptak, Chilton.
2. Optimization of Industrial Unit Processes: Bela G. Liptak

**Reference Books:**

1. Boiler Control Systems: David Lindsey, Mc GRAW HILL
2. Process Control Systems- F. G. Shinskey, TMH



## 406269: Advanced Embedded Systems

<b>Teaching Scheme:</b>	<b>Examination Scheme:</b>	<b>Credits:</b>
Lectures: 3 Hrs/ Week	Paper: (30+70) 100 Marks	Theory: 3
Practical: 2 Hrs/ Week	In semester Assessment: 30 Marks	Oral+TW: 1
	End Semester Assessment: 70 Marks.	Total: 4 Credits
	Oral: 50 Marks	
	Term Work: 25 Marks	

**Prerequisites:** The students should be conversant with microcontroller architecture, microcontroller interfacing, instructions and programming.

**Course Outcomes (COs):** On completion of the course, the students will be able to

1. Independently design and implement an advanced embedded system based on an 16/32-bit microcontroller.
2. Develop software and hardware for embedded systems using ARM microcontroller.
3. Design, structure and realize microcontroller systems with ARM
4. Identify the functionality of development boards to implement ARM embedded applications.
5. Design and develop real time ARM embedded systems used in industry.

### **Unit I: Introduction to ARM Microcontroller (07)**

Pipeline Characteristics, RISC and ARM design philosophy, ARM family, ARM Core & Architecture - Arithmetic Logic Unit, Booth multiplier, Barrel shifter, Control unit, register file, ARM Functional Diagram, ARM Instruction set, Instruction cycle timings and programming

### **Unit II: ARM-32-bit Microcontroller (07)**

Thumb-2 technology and applications of ARM, Architecture of ARM Cortex M3, Various Units in the architecture, General Purpose Registers, Special Registers, exceptions, interrupts, stack operation, reset sequence, ARM Instruction Set - Thumb Instruction Set

### **Unit III: ARM7 Microcontroller (08)**

ARM7 LPC2148 Microcontroller Architecture, Block Diagram, Features, Memory Mapping, serial communication interface - USB 2, full speed device, multiple UARTs, SPI, SSP to 12C. 32-bit timers, 10 bit DAC, 10 bit ADC, PWM channel, fast GPIO lines and level sensitive external interrupts pins.

### **Unit IV: Peripheral interface for Arm Processor (07)**

ARM Bus technology, AMBA Bus Protocol, Memory Controllers, Interrupt Controllers - Standard interrupt controller (SIC), Vector interrupt controller (VIC)

### **Unit V: THUMB and ARM Programming (07)**

ARM and THUMB differences, Register usage in Thumb, ARM Thumb Interworking. Embedded C/C++, General Structure of ARM assembly module, Assembler directives AREA,



ENTRY, END, SPACE, DCD, DCB, DCW, DCI, DCQ, EQU, EXPORT, ALIGN, CODE16, CODE32, DATA

### **Unit VI: ARM Application development (07)**

IoT based project using PLC2148 and WiFi module.

LPC2148 Home Automation and Smart Home systems using Bluetooth

#### **List of Experiments:**

Students are expected to perform minimum eight experiments.

**Note: Each practical write-up should include design, algorithm, flowchart, coding and output**

1. Simple programs on Arithmetic & logical operations, Factorial, string operation, sorting using KEIL MKD for LPC2148
2. Write programs to turn ON/OFF LED using interrupt in ARM Assembly and ARM Embedded C.
3. Write programs to interface LCD in 4-bit mode in ARM Assembly and ARM Embedded C.
4. Write programs use of ADC in ARM Assembly and ARM Embedded C.
5. Write programs to interface LCD in 4-bit mode in ARM Assembly and ARM Embedded C.
6. Write programs to generate various waveforms (square, triangular, sawtooth) using DAC in ARM Assembly and ARM Embedded C.
7. Write programs to interface stepper motor and rotate in clockwise and anticlockwise in ARM Assembly and ARM Embedded C.
8. Write programs to interface Bluetooth with LPC21048.
9. Write programs to interface USB with LPC21048
10. Write program to display Day, Month and Year using RTC of LPC2148 on LCD

#### **Text Books:**

1. Arm System-on-chip Architecture, 2nd Edition 2015, Steve B. Furber, Pearson.
2. Microcontroller (ARM) and Embedded Systems, Raghunandan G. H., Cengage Learning India Pvt. Ltd., 2020.
3. ARM Assembly Language: Fundamentals and Techniques, Second Edition 2014, William Hohl, CRC Press.
4. A Getting Started Guide for MDK Version 5, Keil.

#### **Reference Books:**

1. Embedded Systems Fundamentals with Arm Cortex-M based Microcontrollers: A Practical Approach, Alexander G. Dean, ARM Education Media.
2. ARM Architecture Reference Manual, Second Edition, David Seal, Addison-Wesley.
3. ARM System Developer's Guide: Designing and Optimizing System Software, Andrew Sloss, Dominic Symes, Chris Wright, Morgan Kaufmann



# Elective- V

## 406270: Elective- V A) Electric Vehicles

### Teaching Scheme:

Lectures: 3 Hrs/ Week

### Examination Scheme:

Paper: (30+70) 100 Marks

In semester Assessment: 30 Marks

End Semester Assessment: 70 Marks.

### Credits:

Theory: 3

Total: 3 Credits

**Prerequisites:** Electrical drives.

**Course Outcomes (COs):** On completion of the course, the students will be able to

1. Select appropriate source of energy for the hybrid electric vehicle based on driving cycle.
2. Analyze the power and energy need of the various hybrid electric vehicle.
3. Measure and estimate the energy consumption of the Hybrid Vehicles.
4. Evaluate energy efficiency of the vehicle for its drive trains.

### **Unit I: Introduction to Electric Vehicle (05)**

History of Electric Vehicles, Development towards 21<sup>st</sup> Century, Types of Electric Vehicles in use today - Battery Electric Vehicle, Hybrid (ICE & others), Fuel Cell EV, Solar Powered Vehicles.

Motion and Dynamic Equations of the Electric Vehicles: various forces acting on the Vehicle in static and dynamic conditions.

### **Unit II: Induction to Hybrid Electric Vehicle (05)**

Social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid

Drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.

### **Unit III: Electric Drive Trains (10)**

Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis. Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.

### **Unit IV: Types of Storage Systems (09)**

Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices. Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Calculation for the

ratings.

### **Unit V: Modelling of Hybrid Electric Vehicle Range (07)**

Driving Cycles, Types of Driving Cycles, Range modelling for Battery Electric Vehicle, Hybrid (ICE & others), Fuel Cell EV, Solar Powered Vehicles. Case study of 2-wheeler, 3-wheeler and 4 wheeler vehicles.

### **Unit VI: Energy Management Strategies (06)**

Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies. Introduction to various charging techniques and schematic of charging stations.

#### **Text Books:**

1. James Larminie, J. Lowry, "Electric Vehicle Technology Explained", John Wiley & Sons Ltd. 2003.
2. M. Ehsani, Y. Gao, S. E. Gay and A. Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design", CRC Press, 2004.

#### **Reference Books:**

1. S. Onori, L. Serrao and G. Rizzoni, "Hybrid Electric Vehicles: Energy Management Strategies", Springer, 2015.
2. Iqbal Hussein, "Electric and Hybrid Vehicles: Design Fundamentals", CRC Press, 2003.

#### **List of Open-Source Software/learning website:**

- Online course: <https://nptel.ac.in/course.html>
- [Ocw.mit.edu/courses](https://ocw.mit.edu/courses)
- <https://www.eng.mcmaster.ca/mech/content/electric-and-hybrid-vehicles>

## 406270: Elective- V B) Safety Instrumentation System

<b>Teaching Scheme:</b>	<b>Examination Scheme:</b>	<b>Credits:</b>
Lectures: 3 Hrs/ Week	Paper: (30+70) 100 Marks	Theory: 3
	In semester Assessment: 30 Marks	Total: 3 Credits
	End Semester Assessment: 70 Marks.	

**Course Outcomes (COs):** On completion of the course, the students will be able to

1. To understand the need for SIS in process Industries.
2. To know the associated SIS standards.
3. To implement hazard analysis & risk assessment to identify process hazards & risks.
4. To determine the target SIL & safety requirements specifications
5. To develop detailed SIS design, installation & operation.
6. To implement SIS analysis & design for a furnace/ fired heater system.

### **Unit I: Introduction (08)**

Safety Instrumented System (SIS): need, features, components, difference between basic process control system and SIS - Risk: how to measure risk, risk tolerance, Safety integrity level, safety instrumented functions - Standards and Regulation - HSE-PES, AICHE-CCPS, IEC-61508, ANSI/ISA-84.00.01-2004 (IEC 61511 Mod) & ANSI/ISA - 84.01-1996, NFPA 85, API RP 556, API RP 14C, OSHA (29 CFR 1910.119 - Process Safety Management of Highly Hazardous Chemicals, SIS design cycle.

### **Unit II: Process control vs. Safety control (06)**

Definition of Control and Safety, Process Control - Active/Dynamic, The Need for Making Frequent Changes, Safety Control - Passive/Dormant, The Need for Restricting Changes, Demand Mode vs. Continuous Mode, Separation of Control and Safety Systems-HSE - PES, AICHE - CCPS, IEC 61508, ANSI/ISA-84.00.01-2004, API RP 14C, API RP 554, NFPA 85, IEEE 603, Common Cause and Systematic/Functional Failures- Human Issues.

### **Unit III: Protection layers and safety requirement specifications (06)**

Prevention Layers: Process Plant Design, Process Control System, Alarm Systems, Procedures, Shutdown/Interlock/Instrumented Systems (Safety Instrumented Systems – SIS), Physical Protection - Mitigation Layers: Containment Systems, Scrubbers and Flares, Fire and Gas (F&G) Systems, Evacuation Procedures - Safety specification requirements as per standards, causes for deviation from the standards

### **Unit IV: Safety Integrity Level (SIL) (06)**

Evaluating Risk, Safety Integrity Levels, SIL Determination Method: As Low As Reasonably Practical (ALARP), Risk matrix, Risk Graph, Layers Of Protection Analysis (LOPA) - Issues related to system size and complexity -Issues related to field device safety - Functional Testing.



### **Unit V: System Evaluation (08)**

Failure Modes, Safe/Dangerous Failures, Detected/Undetected Failures, Metrics: Failure Rate, MTBF, and Life, Degree of Modeling Accuracy, Modeling Methods: Reliability Block Diagrams, Fault Trees, Markov Models - Consequence analysis: Characterization of potential events, dispersion, impacts, occupancy considerations, consequence analysis tools - Quantitative layer of protection analysis: multiple initiating events, estimating initiating event frequencies and IPL failure probabilities

### **Unit VI: Case Study (08)**

SIS Design check list - Case Description: Furnace/Fired Heater Safety Shutdown System: Scope of Analysis, Define Target SILs, Develop Safety Requirement Specification (SRS), SIS Conceptual Design, Lifecycle Cost Analysis, verify that the Conceptual Design Meets the SIL, Detailed Design, Installation, Commissioning and Pre-startup Tests, Operation and Maintenance Procedures.

### **Text Books:**

1. Paul Gruhn and Harry L. Cheddie, "Safety Instrumented systems: Design, Analysis and Justification", ISA, 2nd edition, 2018.
2. Eric W. Scharpf, Heidi J. Hartmann, Harlod W. Thomas, "Practical SIL target selection: Risk analysis per the IEC 61511 safety Lifecycle", exida 2nd Edition 2016

### **Reference Books:**

1. William M. Goble and Harry Cheddie, "Safety Instrumented Systems Verification: Practical Probabilistic Calculations" ISA, 2005.
2. Edward Marszal, Eric W. Scharpf, "Safety Integrity Level Selection: Systematic Methods Including Layer of Protection Analysis", ISA, 2002.
3. Standard - ANSI/ISA-84.00.01-2004 Part 1 (IEC 61511-1 Mod) "Functional Safety: Safety Instrumented Systems for the Process Industry Sector - Part 1: Framework, Definitions, System, Hardware and Software Requirements", ISA, 2004.

## 406270- Elective- V: C) Renewable Energy Systems

<b>Teaching Scheme:</b>	<b>Examination Scheme:</b>	<b>Credits:</b>
Lectures: 3 Hrs/ Week	Paper: (30+70) 100 Marks	Theory: 3
	In semester Assessment: 30 Marks	Total: 3 Credits
	End Semester Assessment: 70 Marks.	

**Prerequisites:** Energy system, Energy Transition Systems and Technologies, Renewable energy sources, Flexibility demand, Energy storage, Potential category

### Course Outcomes:

On completion of the course, the students will be able to:

1. Understand the concept of distributed generation with renewable energy sources and know its main types
2. Know the operation and comparative analysis of different concentrating solar power systems.
3. Describe the complexities of energy systems and power grids, and the requirements and industrial impacts of integration, automation and optimization
4. Calculate the major parameters of sun movement, solar radiation, and tracking systems
5. Analyse the types of algorithms and understanding and familiarity with engineering and financial aspects of projects
6. Understand major concepts of wind energy. Calculate air parameters at different conditions, impact of installation height, wind power and average wind power
7. Design in order implement and improve a component, process, or integrated system of people, materials, information, equipment, and energy to meet desired needs within realistic constraints

### Unit I: Renewable Energy Sources (05)

Introduction to various sources of renewable such as solar, wind, hydro, tidal, geothermal etc. Geographical conditions and availability of energy in various parts of the world. comparison of various renewable energy sources. Efficiency and cost considerations. Installation feasibility and requirements.

### Unit II: Solar Photovoltaic Energy (06)

Introduction to various types of photovoltaic solar cells such as, crystalline, polycrystalline, amorphous, thin films etc. Efficiency considerations. Structure of solar panels, characteristics, effect of temperature, irradiation and wavelength spectrum. Standard panel ratings, Solar cells, types, construction, characteristics and efficiency. Solar photovoltaic panels construction, characteristics specifications. Effect of temperature, irradiance and shading.

### Unit III: Energy storage systems (07)

Various types of batteries such as Pb-acid, lithium ion, Ni-MH etc. Their characteristic, specifications and selection. Charging techniques for batteries. Storage media such as fuel cells, fly wheels, super capacitors etc. Their characteristics and applications.

#### **Unit IV: Energy estimation and panel sizing (08)**

Calculation of energy requirement for various loads, solar panel selection and array design. Series and parallel operation of solar panels. MPPT algorithms, solar panel mounting & tracking. Isolated and non-isolated type of solar photovoltaic system, Various types of power converters and their role in solar photovoltaic system. Energy monitoring and metering system.

#### **Unit V: Applications of Renewable Energy (06)**

Solar water heater, solar cookers. Solar power generation plants. Roof top solar photovoltaic electrical energy systems, solar water pumps, solar electric vehicles and chargers, solar street lamps, Solar powered UPS. Battery charging. Grid tied inverters and specifications.

#### **Unit VI: Wind Energy (08)**

Wind energy conversion technologies, aerodynamics of wind turbine rotor, site selection. Wind resource assessment, various models to predict wind pattern and their analysis, concept of wind farms, various aspects of wind turbine design, hybrid wind energy systems- Wind + diesel power, wind + conventional grid, wind + photovoltaic system etc.

#### **Text Books:**

1. Tiwari G N; Solar Energy : Fundamentals, Design, Modelling and Application; Narosa publication.
2. S. Sukhatme, J Nayak; Solar Energy: Principles of Thermal Collection and Storage; 3<sup>rd</sup> edition, Mc. Graw Hill.
3. Solanki C.S; Solar Photovoltaic Technology and Systems: A Manual for Technicians; 1st edition, PHI.
4. Pramod Jain; Wind Engineering, 2nd edition; Mc.Graw Hill.

#### **Reference Books:**

1. Fang Lin Luo, Ye Hong; Renewable Energy Systems: Advanced Conversion Technologies and Applications; 1st edition; CRC Press.
2. D. Yogi Goswami, Frank Kreith; Energy Efficiency and Renewable Energy Handbook; 2nd edition, CRC Press.

## 406270- Elective- V: D) Optical Instrumentation

### Teaching Scheme:

Lectures: 3 Hrs/ Week

### Examination Scheme:

Paper: (30+70) 100 Marks

In semester Assessment: 30 Marks

End Semester Assessment: 70 Marks.

### Credits:

Theory: 3

Total: 3 Credits

**Prerequisite:** Sensors and transducers, Applied Physics, Electronic Instrumentation.

### Outcomes:

1. Apply optical fiber for various signal transmission.
2. Design, Analyze and perform optical power budget.
3. Apply suitable optical sensor technology on various parameters of measurements.
4. Apply appropriate LASER for various applications.
5. Suggest and apply different technology for signal amplification
6. Use optical measuring instruments.

### Unit I: Basics of Optical fiber (07)

Principles of light propagation through a fibre, Ray theory of transmission, total internal reflection, electromagnetic mode theory of optical propagation, cylindrical fiber, classification of fibers and their properties, fibre Connectors and splices -Fibre termination. Overview of optical sources and Optical detectors

### Unit II: Characteristics of optical fiber (07)

Manufacturing of optical fiber, Attenuation, material absorption losses, scattering losses, nonlinear and linear scattering, fiber bend loss, dispersion, intermodal dispersion, dispersion modified single mode fiber, and dispersion flattened fibers, polarization, nonlinear phenomena. Concept of design of optical link and Optical link power budget

### Unit III: Optical fiber sensors (07)

Introduction to fiber optics sensors, sensors based on intensity modulation, application of optical fiber for displacement, strain, stress and pressure measurement. Active multimode FO sensors, micro-bend optical fiber sensors, current sensors, phase modulated, polarization modulated optical fiber sensors, fiber optic gyroscope.

### Unit IV: LASER (07)

Introduction, Fundamental characteristics of lasers - Three level and four level lasers, Properties of laser, Laser modes, Resonator configuration, Q-switching and mode locking, Cavity damping. Types of lasers: Gas lasers, solid lasers, liquid lasers, semiconductor lasers. Application of LASER in biomedical instrumentation and industry in general, LASER interferometry, Holography: basic principle and applications.

### Unit V: Optical amplification and integrated optics (07)

Optical amplifiers, integrated optics integrated optical devices: beam splitters, directional couplers, modulators, switches, optoelectronics integration and differentiation, analog



arithmetic operations, digital optics.

### **Unit VI: Optical Measuring instruments and Optical Computing (07)**

LED light sources and Tunable laser sources, Fiber optic cable tester, Optical Power meter, Optical Time Domain Refractometer (OTDR), Optical Spectrum Analyzer, Fiber optical Numerical Aperture Measurement, Optical Computing: Concept, gates, memory cell, switch.

#### **Text Books:**

1. Optical fiber Communications Principles and Practice- John M. Senior, PHI publication, 2<sup>nd</sup> ed., 2008
2. Optical fiber sensing technology - Ed. Jose Miguel Lopez-Higuera, John Wiley & Sons, 2002
3. Optoelectronic Devices and Systems- S. C. Gupta, PHI learning Pvt. Ltd EEE (Edition) 2010

#### **Reference Books:**

1. LASER Electronics -Joseph T Verdeyen, Prentice Hall of India, 3<sup>rd</sup>ed., 2003
2. Integrated Optics-Theory and Technology, R G Hunsperger, Sixth edition, Springer (2009)
3. Sensor Technology- Ed. Jon S. Wilson, Imprint: Newnes, Elsevier, 2004,
4. Optoelectronics - An Introduction - Wilson and Hawkes, Prentice Hall of India, 1998
5. Optical Fiber Sensors, John Dakin and Brian Culshaw, Artech House 1997.
6. Optics- Ajoy Ghatak- Tata Mc- Graw Hill Publishing, 5<sup>th</sup>ed., 2012
7. Optical holography principles techniques and applications- P. Hariharan
8. Optical fiber communications- Gerd Keiser-McGraw Hill, 4<sup>th</sup> ed.





# Elective- VI

## 406271: Elective- VI A) Cyber Security

### Teaching Scheme:

Lectures: 3 Hrs/ Week

### Examination Scheme:

Paper: (30+70) 100 Marks

In semester Assessment: 30 Marks

End Semester Assessment: 70 Marks.

### Credits:

Theory: 3

Total: 3 Credits

**Prerequisites:** Operating system basics.

**Course Outcomes (COs):** On completion of the course, the students will be able to

1. Use cryptographic techniques in secure application development.
2. To apply the scientific method for security assessment
3. To develop computer forensics awareness.
4. Use cryptographic techniques in secure application development.
5. Designing and hardening security systems.

### Unit I: Introduction to cyber security (06)

An Overview of Information Security: The Basic Components, Threats, Policy and Mechanism, Assumptions and Trust, Assurance, Operational Issues, Human Issues, Security nomenclature.

Introduction to cybercrime and cyber law, cyber space and information technology, Nature and scope of cyber crime, Jurisdiction of cybercrime.

### Unit II: Modular Arithmetic and Cryptography Basics (08)

Modular Arithmetic : Modular Arithmetic Notations, Modular Arithmetic Operations, Euclid's method of finding GCD, The extended Euclid's algorithm. Euler's theorem, Fermat theorem, Chinese remainder theorem. Cryptography : Classical encryption techniques, Block and Chain ciphers, Data Encryption Standard, Advanced Encryption Standard, RC5

### Unit III: Advanced Cryptography (08)

Diffie-Hellman key exchange algorithm, RSA algorithm, Elgamal Arithmetic, Elliptic Curve Cryptography, Message Digest: MD4, MD5. Cryptographic Hash Functions: SHA-1, Digital Signatures and Authentication.

### Unit IV: Network Security (08)

Public Key Infrastructure (PKI), X.509 Certificate, Needham Schroeder algorithm and Kerberos. IP Security: IPv6 and IPSec, Web Security: SSL, HTTPS, Mail Security: PGP, S/MIME . Firewall : Different Types and Functionalities

### Unit V: Issues in Security Management and Cyber Laws (08)

Overview, Risk identification, Risk Assessment, Risk Control Strategies, Quantitative vs. Qualitative Risk Control Practices. Risk Management. Laws and Ethics in Information Security, Codes of Ethics, Protecting programs and data Cybercrime and Information security, Classification of Cybercrimes, The legal perspectives- Indian perspective, Global

perspective, Categories of Cybercrime, Types of Attacks, a Social Engineering, Cyber stalking, Cloud Computing and Cybercrime.

### **Unit VI: Cyber Forensics (08)**

Windows Forensic Analysis: Window artifacts, Evidence volatility, System time, Logged on user(s), Open files, MRUs, Network information, Process information, Service information, Windows Registry, Start-up tasks, Memory dumping; Document Forensics: PDF structure, PDF analysis, MS Office Document structure and analysis, Macros, Windows thumbnails, Mobile Forensics, Network Forensics; Cyber crime investigation: Pre investigation, SOP for Investigation; Case scenarios: social media crime, Online defacement crime, Email investigation

#### **Text Books:**

1. William Stallings, Computer Security: Principles and Practices, Pearson 6 Ed, ISBN 978-0-13-335469-0
2. Nina Godbole, Sunit Belapure , Cyber Security- Understanding Cyber Crimes, Computer Forensics and Legal Perspectives, Wiely India Pvt.Ltd, ISBN- 978-81-265-2179-1

#### **Reference Books:**

1. Bruice Schneier , Applied Cryptography- Protocols, Algorithms and Source code in C, Algorithms, Wiely India Pvt Ltd, 2nd Edition, ISBN 978-81-265-1368-0.
2. CK Shyamala et el., Cryptography and Security, Wiley India Pvt. Ltd, ISBN-978-81-265-2285-9.
3. Berouz Forouzan, Cryptography and Network Security, TMH, 2 edition, ISBN -978-00-707-0208-0.
4. Mark Merkow, Information Security-Principles and Practices, Pearson Ed., ISBN- 978-81-317-1288-7.

## 406271: Elective- VI: B) Automation in Agriculture

<b>Teaching Scheme:</b>	<b>Examination Scheme:</b>	<b>Credits:</b>
Lectures: 3 Hrs/ Week	Paper: (30+70) 100 Marks	Theory: 3
	In semester Assessment: 30 Marks	Total: 3 Credits
	End Semester Assessment: 70 Marks.	

**Program Outcomes:** Student should be able to

1. Demonstrate agricultural properties and functions of sensors used.
2. Demonstrate and explain the use of various equipment's in agricultural.
3. Develop automation scheme for irrigation and green house.
4. Demonstrate working of various continuous and batch processes.
5. Explain and significance of various standards related to food and safety.
6. Develop SCADA and PLC system for cold storage, typical packaging.

### **Unit I: Agro-Meteorological Measurements (07)**

Necessity of instrumentation & control for agriculture, theory and working principles of barometers, fine wire thermocouples, sunshine recorder, infrared thermometer, psychrometers, hair hygrometer, thermo- hygrograph, instruments for measuring soil moisture; soil characteristics, working principles of rain gauge, self-recording rain gauge, Wind instruments: working principles of anemometer, wind vane, anemograph

### **Unit II: Instruments in Agriculture (07)**

Automation in earth moving equipment & farm equipment, implementation of hydraulic, Pneumatic & electronics control circuits in harvesters cotton pickers, tractor etc. Classification of pumps: pump characteristics, pump selection & installation. Automatic weather station – data logger and sensors, nano-sensors for measurement of weather variables; computation and interpretation of data

### **Unit III: Instrumentation in Irrigation and Green house System (07)**

Irrigation systems: necessity, irrigation methods: overhead, centre pivot, lateral move, micro irrigation systems, soil moisture measurement methods: resistance-based method, voltage based method, thermal based method, details of gypsum block, irrigation scheduling, irrigation efficiencies, Application of SCADA for DAM parameters & control. Green houses & instrumentation: ventilation, cooling & heating, wind speed, temperature & humidity, rain gauge carbon dioxide enrichment measurement & control

### **Unit IV: Instrumentation in Process industry (07)**

Flow diagram, detailed processes carried out, instrumentation and control required for Sugar Industry, distillery plant, Milk processing and other dairy products plant

### **Unit V: Food Processing (07)**

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 VI: Automation in Food Industry (07)**

Application of SCADA & PLC in food packing industry, Trends in modern food processing, Equipments for creating and maintaining controlled atmosphere.

#### **Text Books:**

1. D. Patranabis, "Principles of Industrial instrumentation", TMH (2010), ISBN-13: 978-0070699717
2. Michael. A.M, "Irrigation: Theory and Practice", Vikas Publishing House Pvt Ltd, Second edition (2008), ISBN-13: 978-8125918677
3. Curtis D. Johnson, "Process control and instrumentation technology", , 8th Edition, 2015 ,Person, ISBN: 9789332549456, 9332549451
4. Akalank Kumar Jain , Vidhi Jain "Food Safety and Standards Act, Rules & Regulations", Akalank Publications; 13th Edition edition (2015), ISBN-13: 978-8176393584
5. Rosana G. Moreira, "Automatic Control for Food Processing Systems (Food Engineering Series)", Springer; 2001 edition (28 February 2001), ISBN-13: 978-0834217812

#### **Reference Books:**

1. Bela G. Liptak , "Instrument Engineers' Handbook, Process Control and Optimization", CRC Press; 4 edition (29 September 2005), ISBN-13: 978-0849310812.
2. Robert H. Brown, " CRC Handbook of Engineering in Agriculture, Volume II: Volume 1 (C R C SERIES IN AGRICULTURE)", CRC Press; 1 edition (30 June 1988), ISBN-13: 978-0849338625



## 406271- Elective- VI: C) Environmental Instrumentation

**Teaching Scheme:**

Lectures: 3 Hrs/ Week

**Examination Scheme:**

Paper: (30+70) 100 Marks

In semester Assessment: 30 Marks

End Semester Assessment: 70 Marks.

**Credits:**

Theory: 3

Total: 3 Credits

Pre-requisite subject: Sensor & Transducers I & II, Instrumental Methods for Chemical Analysis

**Course Outcomes (COs):** On completion of the course, the students will be able to

1. Design instrumentation systems for environment monitoring.
2. Develop methodology for waste water treatment.
3. Measure and analyse air quality and other parameters.
4. Measure and analyse water quality.
5. Provide solution to reduce pollution

**Unit I: Introduction (07)**

Necessity of instrumentation & control for environment, sensor requirement for environment . Instrumentation methodologies: Ultraviolet analyzers, total hydrocarbon analyzers using flame, ionization detector, Gas chromatography in environmental analysis, photo ionization, portable & stationary analytical instruments.

**Unit II: Quality of water (07)**

Standards of raw & treated water, sources of water & their natural quality, effects of water quality.

Water quality parameters: Thermal conductivity, detectors, Opacity monitors, pH analyzers & their application, conductivity analyzers & their application. Water treatment: Requirement of water treatment facilities, process design.

**Unit III: Sedimentation & Flotation (07)**

General equation for settling or rising of discrete particles, hindered settling, effect of temperature, Viscosity, efficiency of an ideal settling basin , reduction in efficiency due to various causes, sludge, storage & removal, design criteria of settling tank, effect of temperature on coagulation.

Ground water monitoring: Level measurement in ground water monitoring wells, laboratory analysis of ground water samples, instrumentation in ground water monitoring, instrumentation in assessment of soil & ground water pollution.

**Unit IV: Waste Water and Flow Monitoring System (07)**

Automatic waste water sampling, optimum waste water sampling locations, and waste water measurement techniques. Instrumentation set up for waste water treatment

plant. Latest methods of waste water treatment plants, Chemical Oxygen Demand (COD), Biochemical Oxygen Demand ( BOD)

Flow monitoring: Non open channel flow measurement, open channel waste water

flow measurement. Rain water harvesting: necessity, methods, role of NGOs & municipal corporation

### **Unit V: Air Pollution and Sound Monitoring Systems (07)**

Definitions, energy environment relationship, importance of air pollution, Air sampling methods & equipments, analytical methods for air pollution studies. Control of air pollution. Sound pollution: basics of sound pollution, its effect to environment. Acoustic noise measurement & monitoring, Environmental Laws

### **Unit VI: Instruments in Weather station (07)**

Instruments in Weather station like Barometer, Rain gauge, Ceilometer etc., Global environmental analysis, Virtual Instruments in Environmental Engineering Laboratory, Rover Environmental Monitoring station (REMS).

#### **Text Books:**

1. Walter J Weber, "Physico-chemical processes for water quality control", Wiley Inter-science Publications 2012.
2. M N Rao and S K S Rao, " Air pollution", TMH publications 26th reprint 2007.
3. Rao, M. N. and Rao, H. V. N, " Air Pollution", Tata McGraw Hill Publishing Company Limited, New Delhi, 1989, ISBN-13: 978-0074518717
4. Kenneth Wark, Cecil F. Warner, Wayne T. Davis, " Air Pollution: Its Origin and Control" , Pearson; 3 edition (13 November 1997), ISBN-13: 978-0673994165
5. Peany Howard S, Donal R Rowe and George Tacho Banoylous Teddy , "Environmental Engineering" . McGraw Hill Education; First edition (1 July 2017), ISBN-13: 978-9351340263
6. Patrick F. Cunniff, " Environmental Noise Pollution" , John Wiley & Sons Inc (4 May 1977) , ISBN-13: 978-0471189435.
7. Gilber M Masters , "Environmental Engineering and Science" , Pearson Education (1997).

#### **Reference Books:**

1. Randy D. Down & Jay H. Lehr, "Environmental Instrumentation & Analysis Handbook", Wiley-Blackwell (7 October 2004), ISBN-13: 978-0471463542

### 406271: Elective- VI: D) Open Elective

<b>Teaching Scheme:</b>	<b>Examination Scheme:</b>	<b>Credits:</b>
Lectures: 3 Hrs/ Week	Paper: (30+70) 100 Marks	Theory: 3
	In semester Assessment: 30 Marks	Total: 3 Credits
	End Semester Assessment: 70 Marks.	

It is expected to offer this elective from other branch with condition that the course contents should not be the same. If the college / Institute wish to start new elective in collaboration with Industry, they are required to approve the elective from university with prior information and permission from BOS Instrumentation and Control Engineering.

### 406272- Project Stage- II

<b>Teaching Scheme:</b>	<b>Examination Scheme:</b>	<b>Credits:</b>
Practical: 12 Hrs/ Week	Term Work: 100 Marks. Oral: 50 Marks	TW: 4 OR: 2 Total: 6 Credits

For the term work the head of the department should constitute the committee of senior faculty Members. A progressive report has to be maintained and should be shown to the external examiner at the time of final exam. The students have to give presentation and a project report has to be prepared. In the project report an evaluation certificate should be there duly signed by external examiner. The oral examination means a comprehensive viva on the project work done.

## 406273: Audit Course- VIII

In addition to credits course, it is recommended that there should be audit course (non-credit course) preferably in each semester from second year. The student will be awarded grade as AP on successful completion of audit course. The student must opt for one of the audit courses per semester, starting in second year first semester. Such audit courses can help the student to get awareness of different issues which make impact on human lives and enhance their skill sets to improve their employability. List of audit courses offered in each semester is provided in curriculum. Each student must choose one audit course from the list per semester. Evaluation of audit course will be done at institute level. Method of conduction and method of assessment for audit courses is suggested.

The student registered for audit course shall be awarded the grade AP and shall be included such grade in the Semester grade report for that course, provided student has the minimum attendance as prescribed by the Savitribai Phule Pune University and satisfactory in-semester performance and secured a passing grade in that audit course. No grade points are associated with this 'AP' grade and performance in these courses is not accounted in the calculation of the performance indices SGPA and CGPA. Evaluation of audit course will be done at institute level itself.

(Ref-[http://www.unipune.ac.in/Syllabi\\_PDF/revised-2015/engineering/UG\\_RULE\\_REGULATIONS\\_FOR\\_CREDIT\\_SYSTEM-2015\\_18June.pdf](http://www.unipune.ac.in/Syllabi_PDF/revised-2015/engineering/UG_RULE_REGULATIONS_FOR_CREDIT_SYSTEM-2015_18June.pdf))

### **Guidelines for Conduction (Any one or more of following but not limited to)**

- Lectures/ Guest Lectures
- Visits (Social/Field) and reports
- Demonstrations
- Surveys
- Mini Project
- Hands on experience on specific focused topic
- Any relevant courses from NPTEL/ SWAYAM/ MOOCs/ ARPIT etc.

### **Guidelines for Assessment (Any one or more of following but not limited to)**

- Written Test
- Demonstrations/ Practical Test
- Presentations
- IPR/Publication
- Report
- Assignments from NPTEL/ SWAYAM/ MOOCs/ ARPIT etc.

### **Audit courses suggested by BoS, Instrumentation Engineering:**

1. Financial Management/ Engineering
2. Value Education
3. Indian history.