SAVITRIBAI PHULE PUNE UNIVERSITY

Syllabus

T. E. Instrumentation & Control

(2019 Course- Credit Based)

Board of Studies

Instrumentation & Control Engineering

(w.e.f. June- 2021)

Savitribai Phule Pune University, Pune

T.E Instrumentation and Control (2019 Course) Credit Based System

SEMESTER- I

CODE	SUBJECT	TEACHING SCHEME		EXAMINATION SCHEME						CREDITS	
				Paper						Theory	PR/OR/TW
		TH	PR	In Semester Assessment	End semester Assessment	PR	Oral	TW	Total		
306261	Embedded Systems	3	2	30	70	50	--	--	150	3	1
306262	Industrial Automation-I	3	4	30	70	50	--	--	150	3	2
306263	Modern Control Theory	3	2	30	70	--	--	25	125	3	1
306264	Operating System	3	0	30	70	--	--	--	100	3	0
306265	Elective-I	3	2	30	70	--	25	--	125	3	1
306266	Seminar	0	1	0	0		0	50	50	0	1
306267	Audit Course-V	-	-	-	-	-	-	-	-	-	-
		15	**11**	**150**	**350**	**100**	**25**	**75**	**700**	**15**	**6**

SEMESTER- II

CODE	SUBJECT	TEACHING SCHEME		EXAMINATION SCHEME						CREDITS	
				Paper						Theory	PR/OR/TW
		TH	PR	In Semester Assessment	End semester Assessment	PR	Oral	TW	Total		
306268	Internet of Things	3	2	30	70	--	50	--	150	3	1
306269	Industrial Automation-II	3	2	30	70	50	--	--	150	3	1
306270	Digital Signal Processing	3	2	30	70	50	--	--	150	3	1
306271	Elective-II	3	2	30	70	0	25	--	125	3	1
306272	Mini Project	--	2	--	--	--	--	25	25	--	1
306273	Internship	--	4	--	--	--	--	100	100	--	4
306274	Audit Course-VI	--	--	--	--	--	--	--	--	--	--
		12	**14**	**120**	**280**	**100**	**75**	**125**	**700**	**12**	**9**

Elective- I (306265)	Elective- II (306271)
Mechatronics & Robotics	Building Automation
Data Science	Machine Learning
Power Electronics	Electrical Drives
Bio Medical Instrumentation	Analytical Instrumentation

SEMESTER- I

306261: Embedded Systems

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: The students should be conversant with digital numbering system, digital electronics, digital logic design, Boolean expressions, sensors and basic programming concepts.

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

1. Design and implement an embedded system based on an eight bit microcontroller,
2. Develop software and hardware for embedded systems using microcontroller.
3. Develop 8051 Assembly level and C programs using 8051 instruction set.
4. Identify the functionality of development boards to implement embedded applications.
5. Demonstrate basic architecture, characteristics, quality attributes and operating systems of embedded systems used in industry.

Unit I: Introduction to Microcontroller 8051 (07)

Blocks of Microcontroller 8051: ALU, PC, DPTR, PSW, Latch, SFRs, General purpose registers. Functions of each pin of 8051. Clock circuit, reset circuit, phase and state in machine cycle and timing diagram of 8051. I/O Ports structure: Port0, Port1, Port2, Port3. Memory organization: Program and Data memory Map, Internal RAM, Internal ROM. External Memory Addressing and Decoding Logic. Stack, Stack Pointer and Stack operation.
Addressing Modes: Immediate, Register, Direct, Indirect, Indexed, Relative and bit addressing. Modes of operation: Power down and idle mode.

Unit II: Timers/Counters, Interrupt, Serial (07)

Timers & Counters: Timers/Counters logic diagram and its operation in various modes.
Configuration of Timer/Counter using SFRs: TMOD, TCON. Interrupt: Interrupt structure, vector address, priority and operation. ISR – Interrupt Service Routine. Configuration of interrupts using SFRs - IE, IP. Serial: Serial Communication in various modes, Configuration using SRFs - SCON, SBUFF, PCON

Unit III: Instructions and Programming (07)

Instruction set: Data Transfer, Arithmetic, Logical, Branching, Machine Control, Stack operations and Boolean operations. Looping, Counting, Sorting, Indexing, Data manipulation, Masking, Stack operation, Conditional programming. Software development cycle: editor, assembler, cross-compiler, linker, compiler. Assembly language and C programming. Assembler Directives: ORG, DB, EQU, END, CODE, DATA. Programming: Time delay loop, Look-up table, Bit addressability. Introduction to Embedded C and Embedded Python.

Unit IV: Interface design (07)

Interface Input Digital Devices: Pushbutton, Matrix keypad. Interface Input Analog Devices: ADC, LM35, Thermocouple, RTD. Interface Output Digital Devices: Relays, LED, 7-segment LED display, LCD display, DC and Stepper motor. Interface Output Analog Devices: DAC

Unit V: Application development (07)

Block diagram, interface design, flowchart, and programming:

Temperature controller using thermocouple and AC heater along with display of set point, process variable and manipulated variable on LCD display. Line tracing robot using stepper motor and color sensors. Washing machine using timer, AC motors, water sensor and safety interlocks.

Unit VI: Concepts of Embedded System (06)

General purpose computer systems, history, classifications, applications, and purpose of embedded systems. Microprocessors and microcontrollers, RISC and CISC controllers, embedded firmware, other system components. Characteristics and quality attributes of embedded systems: Characteristics, Operational & non-operational quality attributes and application specific embedded system. Core of the Embedded System: General Purpose and Domain Specific Processors, ASICs, PLDs. RTOS Based Embedded System: Operating System Basics, Types of Operating Systems, Tasks, Process and Threads, Multiprocessing and Multitasking, Task Scheduling. Introduction to Embedded target boards: Arduino, Raspberry Pi

List of Experiments:

Students are expected to perform minimum eight experiments: **(Any six from 1–9 and any two from 10–12)**

1. Write programs based on various addressing modes and assembler directives.
2. Write programs based on Arithmetic Instructions (8/16 bit Addition, Subtraction, Multiplication, Division) in Assembly and Embedded C.
3. Write programs based on Logical Instructions (AND, OR, Rotate, etc.) in Assembly and Embedded C
4. Write programs based on Branch Instructions in Assembly and Embedded C.
5. Write programs based on Looping, Counting, and Indexing concept in Assembly and Embedded C.
6. Write programs to introduce delay (e.g.1ms Delay) using Timer/Counter in Assembly and Embedded C.
7. Write programs to turn ON/OFF LED using interrupt in Assembly and Embedded C.
8. Write programs to generate various waveforms (square, triangular, sawtooth, trapezoidal) using timers in Assembly and C.
9. Write programs to interface 4x4 matrix keypad in Assembly and Embedded C.
10. Write programs to interface stepper motor and rotate in clockwise and anticlockwise in Arduino /Raspberry Pi with Embedded Python
11. Write programs for temperature control by configuring ADC and switching AC heater

along with display of set point, process variable and manipulated variable on LCD display in Arduino / Raspberry Pi with Embedded Python

12. Write program to control 4 way traffic light control using Timer/Counter in Embedded Python

Text Books:

1. The 8051 Microcontroller Architecture, Programming and Applications by Kenneth J. Ayala, Penram International Publications.
2. "The 8051 Microcontroller and Embedded Systems – using assembly and C", Muhammad Ali Mazidi and Janice Gillespie Mazidi and Rollin D. McKinlay; PHI, 2006 / Pearson, 2006.
3. "Microcontrollers: Architecture, Programming, Interfacing and System Design", Raj Kamal, Pearson Education, 2005.
4. Embedded System Design – Frank Vahid, Tony Givargis, John Wiley.

Reference Books:

1. The 8051 Microcontroller Based Embedded Systems", Manish K Patel, McGraw Hill, 2014, ISBN: 978-93-329-0125-4.
2. Programming and customizing the 8051 microcontroller, Predko Michael, McGraw-Hill, International edition.
3. Embedded Systems – Lyla, Pearson, 2013

306262: Industrial Automation-I

Teaching Scheme:	Examination Scheme:	Credits:
Lectures: 3 Hrs/ Week	Paper: (30+70) 100 Marks	Theory: 3
Practical: 4 Hrs/ Week	In semester Assessment: 30 Marks	Practical: 2
	End Semester Assessment: 70 Marks.	Total: 5 credits
	Practical: 50 Marks	

Prerequisites: Process Loop Elements, Control System Components.

Course Outcomes (COs): The students will be able to

1. Understand the fundamentals of Industrial Automation, PLC & SCADA.
2. Develop Ladder Program using basic & advanced PLC instructions for Sequential & Continuous processes.
3. Interface Analog & Digital I/O devices, Hydraulic & Pneumatic systems and VFD with PLC.
4. Apply Analog PLC functions to given process control applications.
5. Develop SCADA system for given applications.

Unit I: Introduction to Automation and PLC (06)

Automation: Fundamentals of Industrial Automation Need & Role of Automation, Types of Industrial Automation System, Evolution of Automation.

Introduction to PLC: Definition of PLC, Architecture, Types of PLC, PLC Selection. Signal processing of DI-DO-AI-AO Modules, Interfacing of I/O devices to PLC, Sinking & Sourcing and Program Scan & Advantages and Disadvantages of PLC.

Programming Languages: Introduction to PLC Programming Languages as per IEC 61131-3: Ladder Programming (LD), Function Block Diagram (FBD), Instruction List (IL), Structured Text (ST) & Sequential Function Chart (SFC).

Unit II: Basic PLC Programming (08)

PLC input/output instructions, Development of Relay ladder logic, Ladder programming for logic gates & Boolean algebra, Ladder diagram for Process Control. Timers & Counters instruction, Applications of Timers & Counters for industrial process.

Unit III: Advanced PLC Programming (07)

Comparison & Math operations: Equal, Not-equal to, Less than, Greater than, Less than or equal to, Greater than or equal to, Limit test, Mask Compare equal to, Compare expression, ADD, SUB, MUL, DIV, SQR, NEG, AND ,OR,NOR, EX-OR,NOT, CLEAR.

Move, Masked Move, Jump & Label, Skip & Master Control Relay, Bit pattern in a register, Shift Register & Sequencer instructions. Applications using Advanced PLC Programming instructions.

Unit IV: Analog PLC Programming (07)

Analog PLC Operation: Analog Modules & Systems, Analog Signal Processing, Multi-bit data processing. Examples of analog output applications. PID Modules, PID Tuning & Typical PID Functions.

Different Manufactures of PLCs and their revolution. Overview, Siemens PLC, Allen Bradley PLC, Schneider Electric PLC, Omron PLC, Mitsubishi PLC & GE FANUNC and comparison of various instructions

Unit V: PLC Interfacing to HMI, Hydraulic, Pneumatic, VFD& Motion Control (07)

Need of HMI, Advantages of using HMI, PLC Interfacing to Hydraulic & Pneumatic circuits. Need, Objective & Benefits of Drives, Types of Drives, Selection Criteria For Drives, Advantages & Disadvantages of Drives. Working & Construction of VFD, Different Methods of Speed Control, Applications of VFD, Different Modes of VFD Such As PU, External & Network Mode, Interfacing of VFD to PLC. Introduction of Motion Control, Block diagram, Different elements & Applications of Motion Control.

Unit VI: Supervisory Control & Data Acquisition (SCADA) (07)

General definition & SCADA Components. Need of SCADA system, application & benefits, PLCs Vs RTUs, RTU Block diagram, MTU communication interface, Types of SCADA System, Future trends, Internet based SCADA display system, Comparison of different SCADA packages. Trending, Historical data storage & Reporting, Alarm management. Programming techniques for: Creation of pages, Sequencing of pages, Creating graphics & Animation & development of application using SCADA System.

List of Experiments:

Students are expected to perform minimum sixteen experiments:

Any 4 from 1 to 6

1. Introduction to Ladder Programming, develop and simulate Logic gates and Boolean equations.
2. Develop and Simulate Ladder program for simple on-off applications.
3. Develop and Simulate Ladder program for timer applications.
4. Develop and Simulate Ladder program for counter applications.
5. Develop and Simulate Ladder program for cascading of timers & counters.
6. Develop and Simulate Ladder program for Alarm Annunciator System

Any 4 from 7 to 11

7. Develop and Simulate Ladder program for Batch Mixer/any process application.
8. Develop and Simulate Ladder program for any process using sequencer
9. Develop and Simulate Ladder program for Comparison Instruction/ Logical Instruction.
10. Develop and Simulate Ladder program for Mathematical Instruction/Special Mathematical instructions.

11. Develop and Simulate Ladder program for Data movement instructions/ Program flow control instructions.

Any 4 from 12 to 16

12. Develop and Simulate Ladder program for one application of BCD in/Discrete out/BCD out/Analog out.
13. Develop and Simulate Ladder program for one application of Analog in/Analog out.
14. Develop and Simulate Ladder program for PID controller using PLC for Level/Flow/Temp Control Systems.
15. Interfacing PLC to hydraulic & Pneumatic circuits.
16. Interfacing Motion Control systems to PLC.

Any 4 from 17 to 21

17. Design and Develop SCADA System for application.
18. Study of VFD control using PLC.
19. Creating and Configuring a Project and tags in SCADA.
20. Introduction to FBD, develop and Simulate FBD for any process application
21. Introduction to SFC, develop and Simulate SFC for any process application

Text Books:

1. Programmable Logic Controllers: Principles & Applications by John W. Webb, Ronald A. Reis, Prentice Hall of India, 5th ed.
2. Introduction to Programmable Logic Controllers by Gary Dunning, Delmar Thomson Learning, 3rd ed.
3. Programmable Logic Controllers: Programming methods and applications by John R. Hackworth and Frederick D. Hackworth Jr., Pearson publication

Reference Books:

1. Programmable Logic Controller by Frank D Petruzella, McGraw-Hill Education, 5th ed.
2. Programmable Logic Controllers by W. Bolton, Elsevier Newness publication, 4th ed.
3. Programmable Controller by T. A. Huges, ISA publication, 2nd ed.
4. SCADA by Stuart A. Boyer, ISA 1999.

306263: Modern Control Theory

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	TW: 1
	End Semester Assessment: 70 Marks.	Total: 4 credits
	Term Work: 25 Marks	

Prerequisites: Basics of Control Systems, Laplace Transform.

Course Outcomes (COs): The students will be able to learn

1. Analyze dynamics of a linear system by State Space Representation.
2. Determine the stability of a linear system using pole-placement technique.
3. Design state observers.
4. Determine the stability of systems.
5. Realize the structure of a discrete time system and model its action mathematically.

Unit- I: Introduction to State Space (06)

Terminology of state space (state, state variables, state equations, state space and state model), state space representation, physical variable state space representation, phase variable forms (companion forms: controllable canonical form and observable canonical form). Canonical variable forms: diagonal canonical and Jordan canonical forms, determination of transfer function from state space Model.

Unit II: Analysis of control system in state space (07)

Concept of eigen values and eigen vectors, diagonalisation of plant matrix through similarity transformations, Vander Monde matrix, solution of homogeneous state equation, state transition matrix: definition, derivation and properties, computation of state transition matrix by Laplace transform method, Cayley Hamilton method, similarity transformation method, solution of non-homogeneous state equation

Unit III: **Controllability, Observability and stability (07)**

Concept of controllability: definition, controllability matrix, concept of Observability: definition, Observability matrix. Investigation of state controllability and state Observability using Kalman's test, Gilbert's test, concept of asymptotic stability and stability in the sense of Lyapunov, Lyapunov stability analysis (direct method) of continuous time LTI systems

Unit IV: Design concepts in state space (08)

State variable feedback, control system design via pole placement: necessary and sufficiency condition, computation of state feedback gain matrix K through sufficiency condition, Ackermann formula and coefficient comparison method. State observer: necessity, types, theory, principle of duality between state feedback gain matrix K and observer gain matrix Ke, design of full order state observer.

Unit V: Sampled data Control Systems (07)

Introduction to discrete time control systems, necessary for digital control system, block diagram of digital control systems, operation and equivalents of ADC and DAC, analytical equivalent block diagram of digital control system, sampling and reconstruction process, sampling theorem, Operation and transfer function of zero order hold

Unit VI: Analysis of Sampled data Control Systems (07)

Solution of difference equations using Z transforms method, pulse transfer function, stability analysis of discrete time control systems using Jury stability test, bilinear Transformation and Routh stability test.

List of Experiments:

Students are expected to perform minimum eight experiments:

1. Conversion of transfer function model to state space and vice-versa.
2. Computation of state transition matrix using different methods
3. Investigate state controllability of given system.
4. Investigate state Observability of a given system.
5. Design a state feedback controller through pole placement approach.
6. Design full order state observer using principle of duality.
7. Stability analysis of linear system using Lyapunov Functions
8. Find the Response of the discrete time control system for standard inputs.
9. Determine effect of sampling period on stability of discrete time control system
10. Case Study on modern control system

Reference Books:

1. K. Ogata, "Modern Control Engineering", Fourth Edition, Prentice Hall of India, 2002.
2. J. Nagrath and M. Gopal, "Control System Engineering", Second Edition, Wiley Eastern Limited.
3. M. Gopal, "Control Systems, Principles and Design", Second Edition, TMH, New Delhi, 2002.
4. B. C. Kuo, "Automatic Control Systems", Seventh Edition, Prentice Hall of India, New Delhi, 2002.
5. A. Nagoor Kani, Control System, RBA Publications.
6. M. Gopal , Digital Control & State Variable Methods, TMH.

306263: Operating Systems

Teaching Scheme:	Examination Scheme:	Credits:
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: Data structures, File structures, Any structured Programming Language (like C, python),

Course Outcomes (COs): The students will be able to learn

1. Operating systems and their principle
2. Understanding of modern operating system
3. Analyze multi-processing and their applications
4. Apply memory management concepts
5. Analyze safety of operating system.

Unit I: Operating Systems (06)

Operating Systems Overview- Overview and Functions of operating systems, protection and security, distributed systems, operating systems structures, services, system calls and their working. History and generation of operating system.

Unit II: Process Management (08)

Processes: Definition, Process Relationship, Process states , Process State transitions , Process Control Block ,Context switching – Threads – Concept of multithreads , Benefits of threads – Types of threads

Process Scheduling: Definition, Scheduling objectives, Types of Schedulers ,Scheduling criteria : PU utilization, Throughput, Turnaround Time, Waiting Time, Response Time (Definition only) , scheduling algorithms : Preemptive and Non , preemptive , FCFS – SJF – RR , Multiprocessor scheduling : Types , Performance evaluation of the scheduling.

Unit- III: Memory Management (07)

Basic Memory Management: Definition, Logical and Physical address map, Memory allocation: Contiguous Memory allocation – Fixed and variable partition – Internal and External fragmentation and Compaction , Paging : Principle of operation – Page allocation – Hardware support for paging –,Protection and sharing – Disadvantages of paging.

Virtual Memory: Basics of Virtual Memory – Hardware and control structures – Locality of reference, Page fault , Working Set , Dirty page/Dirty bit – Demand paging (Concepts only) – Page Replacement policies : Optimal (OPT) , First in First Out (FIFO), Second Chance (SC), Not recently used (NRU) and Least Recently used (LRU)

Unit- IV: Principles of deadlock (07)

Deadlock - system model, deadlock and its characterization with example, deadlock prevention techniques with example, detection and avoidance of a deadlock, methods to get recovery form deadlock.

Unit- V: File system Management (07)

File system Interface- the concept of a file, Access Methods. Directory structure. File system mounting, file protection and sharing mechanism. File System implementation- File system structure, file/directory implementation, efficiency and performance, file allocation methods, free space management.

Unit- VI: Protection & Security (07)

Protection - Protection. Goals of Protection, Principles of Protection. Domain of protection Access Matrix, Implementation of Access Matrix. Access control, Revocation of Access Rights. Capability- Based systems, Language – Based Protection.

Security -Problems, program threats, system and network threats, cryptography as a security tool, user authentication, implementing security defenses, fire walling to protect systems and networks, computer –security classifications

Reference Books:

1. Operating System Concepts- Abraham Silberchatz, Peter B. Galvin, Greg Gagne, 8th edition.
2. Operating Systems - Internals and Design Principles. Stallings, 6th Edition-2009. Pearson Education.
3. Operating systems- A Concept based Approach-D. M. Dhamdhere. 3rd Edition. TMH
4. Modern Operating Systems, Andrew S Tanenbaum 3rd edition PHI.
5. Principles of Operating Systems, B.L.Stuart. Cengage learning, India Edition.
6. Operating Systems. A.S. Godbo1e.2nd Edition, TMH

306265 A: Elective-I A: Mechatronics & Robotics

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: 25 Marks	

Prerequisites: The students should be familiar with sensors, logic, microcontroller, computer programming and mechanical devices so that they can design the right robot for each application.

Course Outcomes (COs): The students will be able to learn

1. designing mechanical devices that incorporate electrical, software and mechanical components.
2. actuation techniques used in micro electro-mechanical systems
3. analyze various robot structures and their workspace.
4. analyze motion equations and transformations required to design a robot along with robot programming for advanced application.
5. analyze the applications of robots in various industries.

Unit 1: - Fundamentals of Mechatronics (07)

History of Mechatronics, Traditional Vs Mechatronics Based Design, Components of Mechatronics Systems - Mechanical System, Electrical System, Information System, Applications of Mechatronic Systems- Industrial robot, Mobile robot, Flatbed scanner and a Parking-garage gate, Scope of Mechatronics, Advantages of Mechatronics

Unit II: Introduction to MEMS & Applications (07)

MEMS and micro system definition, Sensors used in MEMs and Microsystems (Mechanical Sensing, Capacitive, Electrostatic, Electromagnetic, Piezo Resistive, Piezo Electric, Thin Films, Shape Memory Alloys), Fabrication Methods (Micro fabrication Methods -VLSI Techniques, Metallization Techniques), Introduction to Micro actuators, Micro fluidics and Nanotechnology

Unit III: Design of Mechatronics Systems (07)

Recognition of the Need, Conceptual Design and Functional Specification, Sensor and Actuator Selection, Drivers for Actuators, Control System Design, Design Optimization, Prototyping Hardware-in-the-loop Simulation, Deployment/Life Cycle, Deployment of Embedded Software, Life Cycle Optimization.

Unit IV: Basic Concepts of Robotics (07)
Definition, History of Robotics, Important characteristics of a Robot, Classification of Robots, Sensors in Robotics (proxy, range, ir, ultrasonic, flex etc.), Micro-controllers in Robotics (Arduino, Raspberry Pi), Motors (DC, Bldc, Stepper, Servo), Motor Drivers in Robotics, Safety Measurement in Robotics, Scope of Robotics, Advantages of Robotics, Industrial applications of Robotics.

Unit V: Kinematics & Programming (08)
Direct and Inverse kinematics, Degree of Freedom, Types of gripper, End effectors, Actuators Programming languages for Robots (Python), Algorithm, Classes, Data-structure, OOP. Concept of Artificial Intelligence in Robots

Unit VI: Applications & Advances in Robotics (08)
Line following Robot algorithm and program, Remote controlled car programming.

Development of Robotic Arm – design (using kinematics calculations), selection of components (motors, microcontroller, material), programming of Robotic arm to make it work as a pick and place arm.

List of Experiments:
Students are expected to perform minimum eight experiments:

1. Familiarization with the following Sensors in Robotics proxy, range, infrared, ultrasonic, flex.
2. Familiarization with the following electrical machines: Induction motors, DC motors, synchronous motors, single phase motors.
3. Familiarization with the following mechanical components: gears, gear train, bearings, couplings, tachometer
4. Interfacing stepper motor and temperature sensor
5. Interfacing the wireless Modules with ARM

Exercise on any Robotic Simulation Software

6. Robot Programming and Simulation using linear and nonlinear paths.
7. Writing and running Robot programs – Activity material handling operation.
8. Determination of maximum and minimum position of links
9. Estimation of accuracy, repeatability, and resolution.
10. Measure the knowledge of Robotic arm, material handling, Scorbase Software and Homing and Moving Robot

Text Books:

1. Stephen D. Senturia, Microsystem Design (2007), Springer Science.
2. Introduction to Mechatronics and Measurement Systems, Alciatore and Histand Tata McGraw-Hill
3. Introduction to Robotics By S. K. Saha, Tata McGraw Hill
4. Robotics Control, Sensing, Vision, and Intelligence by K. S. Fu, R. C. Gonzalez, C. S. G.

Lee , Tata McGraw Hill.
5. Mikell P. Groover, Mitchel Weiss, Roger N. Nagel, Nicholas G. Odrey and Ashish Dutta, "Industrial Robotics: Technology, Programming and Applications", 2nd Edition, Tata McGraw Hill, 2012.

References:

1. Fundamentals of Mechatronics by Musa Jouaneh Department of Mechanical, Industrial, and Systems Engineering University of Rhode Island
2. V. Choudhary, K. Iniewski, MEMS: Fundamental Technology and Applications, CRC Press, (2017).
3. Mechatronics System Design, Shetty and Kolk CENGAGE Learning, India Edition
4. J. Hirchhorn: Kinematics and Dynamics of Machinery, McGraw Hill book co.
5. Robert J. Schilling, Fundamentals of Robotics-Analysis and Control, Prentics Hall india.
6. Ghosh, Control in Robotics and Automation: Sensor Based Integration, Allied Publishers, Chennai, 1998.

306265 B: Elective-I B: Data Science

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: 25 Marks	

Prerequisites: Data Structures

Course Outcomes: On completion of the course, learner will be able to–

1. Use data science processes.
2. Demonstrate statistics for data analysis.
3. Describe data science packages.
4. Describe data cleaning methods.
5. Model multi dimensional data and visualize it using appropriate tool.

Unit I: Introduction to Data Science (06)

Data Science Process: Data science Life cycle, Overview, Different steps, Machine Learning Definition and Relation with Data Science Modelling and Compilation, Data Analysis, Data Presentation and Visualization Data Science Software Tools, Programming Languages for Data Science, Applications of Data Science, types of data.

Unit II: Data Sampling and Statistics for Data Analysis (07)

Data Collection and Sampling, Statistics: Descriptive Statistics: Measurement of central tendency (Mean, median and mode), measurement of spread (Range, IQR, variance, standard deviation) , correlation, covariance and Inferential Statistics (Probability, Hypothesis testing)

Unit III: Data Science Packages in details (07)

Numpy: Array Operation, Indexing//slicing, mathematical operations, Matrix operations, String operation.
Pandas: Basic pandas operation on data frame, append, loc and iloc, missing values, merge, concat , join, groupby, pivot, melt, date_time index.
Matplotlib: Histogram, Line chart, bar chart, pie chart, scatter plot, subplot, imshow.
Seaborn: Histogram, line chart, pie chart, bar chart, scatter pot, heatmap, pairplot.
Scipy: used for scientific purpose Sklearn: used for Machine learning

Unit IV: Exploratory data analysis /Data Cleaning (07)

Identification of variables and data types, Univariate, bivariate, multivariate analysis, Variable transformations, Missing value treatment (Mean /median/mode methods) Outlier treatment (Percentile, Std dev, IQR, Boxplot, Z score)

Unit V: Data Cleaning and Data Visualization (06)

Categorical to Numerical: One hot encoding, dummies, Label encoding,

Correlation Analysis, Feature Selection, Feature Rescaling (Normalization and Standardization), Feature Transformation(Log, exponential, square)

Unit VI: Introduction to Data Visualization Tools: Tableau (07)

Introduction To tableau:

- Tableau Desktop: Made for individual use
- Tableau Server: Collaboration for any organization
- Tableau Online: Business Intelligence in the Cloud
- Tableau Reader: Let you read files saved in Tableau Desktop.
- Tableau Public: For journalists or anyone to publish interactive data online.

Tableau desktop : Different types of Databases, Connecting With Data, different types of charts, Creating Views and Analysis, case study.

List of Experiments:

Students are expected to perform minimum eight experiments:

Tools Used : Anaconda, Language = Python , Data Visualization Tool , Tableau

1. Statistical analysis of dataset , Hypothesis testing analysis
2. EDA of Dataset
3. Build training and testing dataset of assignment 1 to predict the probability of a survival of a person based on gender, age and passenger-class.
4. Data Analysis of dataset
5. Predict the age of abalone from physical measurements using linear regression or predict ring class as classification problem.
6. Students performance analysis
7. Data analysis exercise.
8. Tableau dashboard
9. Case study on Tableau dashboard

Text Books:

1. Python for data analysis by O'Reilly
2. Data Visualization in python by Daniel Nelson
3. Mastering Python for Data Science by Samir Madhavan

References:

1. Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing, and Presenting Data by John Wiley & Sons
2. Python for Data Analysis by W McKinney
3. Think Stats: Probability and Statistics for Programmers by Allen B. Downey

306265 C: Elective-I C: Power Electronics

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: 25 Marks	

Prerequisites: The students should be conversant with basic electrical concepts, basic electronics concepts, and electrical and electronic components.

Course Outcomes (COs): The students will be able to learn

1. Design & implement a triggering / gate drive circuit for a power device
2. Understand, perform & analyze different controlled converters.
3. Evaluate battery backup time & design a battery charger.
4. Design & implement over voltage / over current protection circuit.
5. Understand the concept of electromagnetic interference.

Unit I: Power Devices (07)

Construction, Steady state characteristics & Switching characteristics of SCR, Construction, Steady state characteristics of Power MOSFET & IGBT. SCR ratings: IL, IH, VBO, VBR, dv/dt, di/dt, surge current & rated current. Gate characteristics, Gate drive requirements, Gate drive circuits for Power MOSFET & IGBT, opto isolator driving circuits for SCR. Series and parallel operations of SCR's. Applications of above power devices as a switch .

Unit II: AC-DC Power Converters (07)

Concept of line & forced commutation, Single phase Semi & Full converters for R, R-L loads, Performance parameters, Effect of freewheeling diode, Three phase Semi & Full converters for R load, effect of source inductance, Power factor improvement techniques, Diode based boost converter. Single Phase dual converter with inductive load.

Unit III: DC-AC Converters (07)

Single phase bridge inverter for R and R -L load using MOSFET / IGBT, performance Parameters, single phase PWM inverters. Three Phase voltage source inverter for balanced star R load with 120° and 180 mode of operation, Device utilization factor, Harmonics Elimination/Modulation Techniques.

Unit IV: DC-DC converters & AC Voltage Controller (07)

Working Principle of step down chopper for R-L load (highly inductive), control strategies. Performance parameters, Step up chopper, 2-quadrant & 4-quadrant choppers, SMPS: Fly back/ Half Bridge/ LM3524 based or equivalent Circuit. Single-Phase full wave AC voltage controller by using IGBT with R load.

Unit V: Resonant Converters & Protection of Power Devices & Circuits (07)

Need for Resonant converters, Concept of Zero current switching (ZCS) and Zero voltage switching (ZVS) resonant converters. Cooling & heat sinks, over voltage conditions, over voltage protection circuits, metal oxide varistors, over current fault conditions, Over current protection. Electromagnetic interference, sources, minimizing techniques, shielding techniques for EMI.

Unit VI: Power Electronics Applications (07)

ON-line and OFF line UPS with battery AH, back up time, battery charger rating. Electronic Ballast, LED Lamp with Driver Circuit, fan Regulator. Single phase separately excited DC motor drive, stepper motor drive, BLDC motor drive. Variable voltage & variable frequency three phase induction motor drive.

List of Experiments:

Students are expected to perform minimum eight experiments:

1. Study of characteristics and firing circuits of SCR
2. Study of characteristics of MOSFET.
3. Study of Steady-state frequency response of RLC circuit
4. Study of single phase half and full wave controlled rectifier using R and RL loads
5. Study of step-down and step-up DC chopper using R and RL loads
6. Study of Single Phase Series Inverter with R & RL Loads
7. Study of 1Φ voltage controllers using R and RL loads
8. Study of three phase input thyristorised drive for DC motor with closed loop control
9. Study of driver circuits and generation of PWM signals using Microcontroller
10. Study of single phase cyclo converter
11. Study of charging circuit for mobile using chopper
12. Study of DC-AC convertor used in electric vehicles

Text Books:

1. Bimal K Bose, " Modern Power Electronics and AC Drives" PHI
2. N. Mohan et.al. "Power Electronics- Converters, Applications and Design", John Wiley & Sons (Asia) Private Ltd., Singapore.
3. M. H. Rashid, "Power Electronics - Circuits, Devices and Applications", P.H.I Private Ltd. New Delhi.
4. M.D. Singh & K.B. Khanchandani "Power Electronics" Tata McGraw Hill.

References:

1. Sen. P.C. "Thyristor DC Drives", John Wiley and sons, NewYork.
2. Subramanyam, V. "Electric Drives – Concepts and applications", Tata McGraw Hill Publishing Co., Ltd., New Delhi.
3. Joseph Vithayathil, "Power Electronics - Principles and Applications", McGraw Hill Inc., New York.

306265 D: Elective-I D: Bio-Medical 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: 25 Marks	

Prerequisites: Required knowledge of basic body functioning and analog signal conditioning circuits.

Course Outcomes (COs): The students will be able to learn

1. Understand and characterize the origin of bio-potentials and inspect common biomedical signals by their characteristics features and design bio-potential amplifiers.
2. Illustrate measure and analyse related parameters of cardiovascular system and calculate cardiac output.
3. Describe the nervous and muscular systems and related measurements used.
4. Understand anatomy and physiology of special senses and the natural breathing process of the respiratory system, find problems related to it and specify the corrective action to be taken.
5. Operate ECG, EEG, PCG and BP, to monitor measure and analyse heart and brain activities.

Unit I: Bio-potential Measurement: (07)

Electrode-Electrolyte interface, half-cell potential, Polarization- polarisable and non-polarizable electrodes, Ag/AgCl electrodes, Electrode circuit model; motion artifact. Body Surface recording electrodes for ECG, EMG, and EEG. Internal electrodes- needle and wire electrodes. Micro electrodes- metal microelectrodes, Electrical properties of microelectrodes. Electrodes for electric stimulation of tissue Bio-transducers: Physiological parameters & suitable transducers for its measurements, operating principles & specifications for the transducers to measure parameters

Unit II: Cardiovascular System: (07)

Heart Structure, Cardiac Cycle, ECG Theory, ECG Electrodes, Electrocardiograph, Vector cardiograph Analog Signal Processing of Bio-signals, Amplifiers, Transient Protection, Interference Reduction, Movement Artifact Circuits, Active Filters, Rate Measurement, Averaging and Integrator Circuits, Transient Protection Circuits

Unit III: Cardiovascular Measurements: (07)

Heart Sounds, Phonocardiography, Blood Pressure Measurement (Invasive and Non-invasive), Blood Flow meters: Magnetic, Ultrasonic, Thermal Convection Methods, Cardiac Output Measurement (dye dilution method), Plethysmography

Unit IV: Central Nervous System : (07)

Brain & its parts, different waves from different parts of the brain, brain stem, cranium nerves, structure of neuron, Neuro muscular transmission, Electroencephalography, Evoked Response, EEG amplifier, Biofeedback Classification of muscles: Muscle contraction mechanism, Myoelectric voltages, Electromyography (EMG).

Unit V: Special Senses: (07)

I Ear: Mechanism of Hearing, Sound Conduction System, Basic Audiometer; Pure tone audiometer; Audiometer system Bekesy; Evoked response Audiometer system, Hearing Aids
II Vision: Anatomy of Eye, Visual acuity, (Errors in Vision,)

Unit VI: Respiratory Instrumentation: (07)

Natural Process of Breathing, O2 and CO2 Transport, Regulation of Breathing, Spirometers, airflow measurement, Oxygenators-Bubble Type, Membrane Type Gas Analyzers: Infrared gas analyzer, Oxygen analyzer, Nitrogen analyzer, and Ventilators

List of Experiments:

Students are expected to perform minimum eight experiments:

1. To study bio electrodes.
2. To study various preamplifier used in biomedical applications.
3. To Design a Notch Filter for Power Line Frequency.
4. To Study and Check Specifications of an ECG Recorder.
5. To Design and Implement basic ECG Amplifier
6. To Measure Blood Pressure Using Sphygmomanometer, Calibration of BP apparatus
7. To Implement a Heart Rate Meter.
8. To study Phonocardiogram.
9. To study blood flow meters.
10. To Study Electroencephalogram (EEG)/ Electromyogram (EMG)
11. To study of Audiometer.
12. To study of spirogram.
13. To Develop a Photo-plethysmography Sensor for Pulse Rate Measurement.
14. To study the oxygenators.

Text Books:

1. Human Physiology- The Mechanism of Body Function By Vander, Sherman, TMH Ed.1981.
2. Introductions to Biomedical Equipment Technology By Joseph J. Carr & John M. Brown, Publisher, Pearson Education,
3. Biomedical Instrumentation and Measurements By Leslie Cromwell, Fred J. Weibell , 2nd edition, Prentice Hall India Learning Private Limited;.
4. Handbook of Biomedical Instrumentation By R. S. Khandpur, TMH

References:

1. Biomedical Digital Signal Processing, Tompkins, PHI .
2. Biomedical Instrumentation, Dr. M. Arumugam , Anuradha Publications,
3. Text book of clinical Ophthalmology- Ronald Pitts Crick, Pang Khaw, 2nd Edition, World Scientific publication. ISBN 981-238-128-7

306266: Seminar

Teaching Scheme:	Examination Scheme:	Credits:
Practical: 1 Hr/ Week	Term Work: 50 Marks	Term Work: 01 Total: 01 credits

Course Outcomes:

On completion of the course, student will–

1. be able to be familiar with basic technical writing concepts and terms, such as audience analysis, jargon, format, visuals, and presentation.
2. be able to improve skills to read, understand, and interpret material on technology.
3. improve communication and writing skills.

Guidelines:

Each student will select a topic in Instrumentation and Control Engineering preferably keeping track with recent technological trends and development beyond scope of syllabus avoiding repetition in consecutive years.

1. The topic must be selected in consultation with the institute guide.
2. Each student will make a seminar presentation using audio/visual aids for a duration of 20-25 minutes and submit the seminar report.
3. Active participation at classmate seminars is essential.

Guidelines for Assessment:

Panel of staff members along with a guide would be assessing the seminar work based on these parameters-
Topic, Contents and Presentation, regularity, Punctuality and Timely Completion, Question and Answers, Report, Paper presentation/Publication, Attendance and Active Participation.

Recommended Format of the Seminar Report in Ms Word/ Latex:

- Title Page with Title of the topic, Name of the candidate with Exam Seat Number / Roll Number, Name of the Guide, Name of the Department, Institution and Year & University
- Seminar Approval Sheet/Certificate
- Abstract and Keywords
- Acknowledgements
- Table of Contents, List of Figures, List of Tables and Nomenclature
  Chapters Covering topic of discussion- Introduction with section including organization of the report, Literature Survey/Details of design/technology/Analytical and/or experimental work, if any/ Discussions and Conclusions ,Bibliography/References

306267: Audit Course- V

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)

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. Emotional Intelligence
2. Value Education
3. MOOC-Learn New Skills
4. Foreign Language – Japanese /German Module 3

SEMESTER- II

306268: Internet of Things

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: Digital Electronics, Embedded Systems.

Course Outcomes (COs): The students will be able to

1. Present a survey on building blocks of IOT.
2. Compare the connectivity technologies and protocols in IOT.
3. Use IOT platform for application development
4. Discuss Security issues in IOT.
5. Develop Architectural Approach for IOT application

Unit I: Introduction (05)

Industry revolutions, Industry Revolution 4.0 – technology. Definition and characteristic for IOT, Physical Design of IOT, Logical Design of IOT, IOT enabling technologies, IOT levels and Deployment, opportunities and challenges. Building blocks of IOT,
Architecture framework: Cisco Architecture, Underlying Standard, Architecture framework, Industrial Internet Architecture Framework, Industrial Internet Reference Architecture, Industrial Internet Viewpoints, Business Viewpoint, Usage Viewpoint, Functional Viewpoint, Implementation Viewpoint, System Characteristics and Their Assurance,

Hardware required: Sensors, Actuators, Routers, Switches, platforms for IOT.

Unit II : Network (07)

point to point, point to multi point data transfer, OSI model, connectivity terminology, gateway prefix allotment, impact of mobility on addressing, multi homing, IOT protocols: IPV4, IPV6
Physical Layers - IEEE 802.15.4 - The IEEE 802 Committee Family of Protocols - The Physical Layer- The Media-Access Control Layer - Uses of 802.15.4 - The Future of 802.15.4: 802.15.4e and 802.15.4g. The Layering concepts, IOT Communication Pattern, IOT protocol Architecture, The 6LoWPAN Security aspects in IOT
Wireless communication, Wi-HART protocol, MAP/RAP communication, Hardware requirements, OPC-UA protocol, IO-Link Sensors

Unit III: IOT Platform (08)

Definition, Roll, Selection: Scalability, Ease of Use, Third party integration, Deployment option, Data Security, Function of IOT platform, Types of platforms: Application enablement and development, Network, Data and Subscriber Management, Device Management

Physical device – Ardino / Raspberry Pi Interfaces, Hardware requirement of Ardino / Pi, Connecting remotely to the Ardino /Raspberry Pi,GPIO Basics, Controlling GPIO
Using a Web Interface– Programming, APIs / Packages, Arduino Interfaces, Integration of Sensors and Actuators with Arduino, Introduction to Python programming, Industry accepted IOT Protocols like MQTT, Limitations, OSI PI.

Unit IV: Resource Management (07)

Cloud Computing: Architecture, characteristics, deployment cloud models : public, private, hybrid, community cloud, multi cloud, distributed cloud, inter, big data, HPC , Service Models: Infrastructure as a service, Platforms a Service, Software as a service, Data Synchronization.

Identity portrayal, Identity management, various identity management models: Local, Network, Federated and global web identity, user-centric identity management, device centric identity management and hybrid-identity management, Identity and trust.

Unit V: Security in IOT (07)

Concepts, IoT Reference Model, IoT Security, Threats, IoT Security Requirements, IoT Security Overview, IoT Protocols, Network and Transport Layer Challenges, IoT Gateways and security, IoT Routing Attacks, Bootstrapping and Authentication, Authorization Mechanisms IoT OAS, Security Frameworks for IoT, Light Weight Cryptography, Asymmetric LWC Algorithms, Key Agreement, Distribution, and Bootstrapping , Privacy in IoT Networks, Secure Data Aggregation,

Contribution from FP7 Projects, Smartie Approach. Data Aggregation for the IoT in Smart Cities

Unit VI: Case Study & advanced IOT Applications (08)

Smart home: Smart Home Technologies, Smart Home Implementations, Home Area Network,
Smart Grid: Characteristics, Architecture, Benefits, components, Communication, Security, Smart Grid and Cloud.
Smart Cities: Characteristics, framework, Challenges, Data Fusion, Smart Parking, Energy Management.
Connected vehicle: Levels of Automation, Vehicle Networks, Intelligent Connected Vehicle, VNAET Domains, Benefits and Challenges of V2X Communication ,
Smart Health Care System: Clinical Care, Remote Monitoring, Other Interesting Use Cases of IoT, Enabling Technologies which Make IoT in Health Care Possible, Challenges in the IoT Health Care Sector, Future Trends for IoT in Health Care, Ingestible Sensor, Digital Medicine , Mobile Apps in Health Care Sector , Cloud and Big Data Analytics in the Health Care Sector, Cloud Services in Health Care Sector.

List of Experiments:

Students are expected to perform minimum eight experiments:

Following experiments can be performed using any available IOT platform like Arduino/Raspberry Pi/Node32/Intel Edison etc.

1. Interfacing of digital sensor/switch with developing board and display of condition on LED and on LCD
2. Interfacing analogue sensor with developing board and displaying it's value on LCD.
3. Changing brightness of LED using Potentiometer using PWM technique.
4. Interfacing of development boards with python
5. Data transfer from one development board to other using Wi-Fi.
6. Data transfer from one development board to other using Bluetooth.
7. Sending data from development board using GSM using SMS
8. Connecting development board to internet either with Wi-Fi or GSM
9. Sending information to cloud using development board.
10. Receiving data from cloud to development board and displaying it on LCD.

Text Books:

1. Arshdeep Bahga, Vijay Madisetti, "Internet of Things – A hands-on approach", Universities Press, 2015.
2. The Industrial Internet of Things Volume G1: Reference Architecture
3. Jeeva Jose, Internet of Things, Khanna Publisher, Edition: First, ISBN: 9789386173591

References:

1. Hakima Chaouchi, " The Internet of Things Connecting Objects to the Web" ISBN : 978-1-84821-140-7, Willy Publications.
2. Dieter Uckelmann, Mark Harrison, Florian Michahelles,Architecting theInternet of Things, Springer, ISBN 978-3-642-19156-5
3. Rajkumar Buyya, Amir Vahid Dastjerdi, Internet of Things Principles and Paradigms, Morgan Kaufmann, ISBN: 978-0-12-805395-9

306269: Industrial Automation- II

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: Computer operation, data communication and process control loop elements.

Course Outcomes (COs): The students will be able to

1. Understand the fundamentals of DCS Organization in Industrial Automation.
2. Analyze the software and hardware DCS configuration.
3. Analyze the different security design approaches, engineering and operator interface issues for designing Distributed control system.
4. Analyze the latest networking technologies RS232, RS485, OPC, HART and Field bus protocol.
5. Design and development of DCS programming for simple process applications.

Unit I: Introduction to Distributed Control System (DCS) (06)

Distributed Control System (DCS): Introduction, Evolution, Location of DCS in plant, Functions, Architecture: Engineering Workstation and Operating Station, I/O, components, Hardware, software, system interfacing, Features, DCS Specification, Advantages, limitations, Comparison of DCS, PLC, and SCADA

Unit II: DCS Configuration (07)

Distributed Control Systems: Structure and Configuration, DCS block diagrams, Components, Architecture, redundancy concepts, DCS hardware configuration, DCS Hardware & Software Internals: Process variables, software variables, tags, Human Machine Interface (HMI), Alarms, Trends, Databases. Basic DCS Controller Configuration, Sequential Controllers for Batch Processing, Controllers for Continuous Processes: Function Blocks.

Unit III: DCS Networking (08)

Instrumentation Standard Protocols: Definition of protocol, Introduction to Open System Interconnection (OSI) model, Communication standard (RS232, RS485), Modbus (ASCII/RTU), Introduction to third party interface, concept of OPC (Object linking and embedding for Process Control), HART Protocol: Introduction, frame structure, programming, implementation examples, benefits, advantages and limitation. Foundation Fieldbus H1: Introduction, frame structure, programming, implementation examples, benefits, advantages and limitation. Comparison of HART, Foundation Fieldbus, Device net, Profibus, Control net, Industrial Ethernet.

Unit IV: HMI, Alarms, and DCS Operation (07)

Human Machine Interfaces: Introduction, features and requirements. Plant mimic and animation, DCS Operator Stations, Recorders, Loggers, Trend Displays, and Data Archiving, HMI in the Control Room and in the Field: Mobile and remote devices. Alarms philosophy, Control & Management. Development and Applications, Logs, trends, and reports.
DCS Operation, Operational view of DCS, Role of operators, Integration and Optimization of DCS.

Unit V: DCS Programming & Advanced Control (07)

DCS Programming Languages (IEC 61131-3): Function block diagram (FBD), Sequential Function Chart (SFC), Programming Algorithms for Modules, Advanced functions like, fuzzy logic, ANN and MPC for process control.

Unit VI: Latest DCS Trends and Applications (07)

Monitoring and control in the Field, Industrial Internet, Internet of Things and Mobile and remote devices.
Application : DCS support to Enterprise Resources Planning (ERP), Use of DCS in pulp and paper environment, petroleum-refining environment and oil and gas processing environment.

List of Experiments:

Students are expected to perform minimum eight experiments:

1. To study of detail architecture of any typical DCS system.
2. To start and stop electric motor/Pump using DCS.
3. To connect field device (Transmitter and Control Valve) and its configuration for input and output channels in DCS
4. To find empirical process model of any simple process using DCS.
5. To develop and implement simple feedback control loop using PID function block in DCS.
6. To configure the historical data, graphics and faceplate for above feedback control loop.
7. To study of HART and field bus networks.
8. To study of field bus-based field device and its configuration.
9. Case study of DCS for any Industrial application.
10. To prepare specification sheet of DCS for any industrial application.

Text Books:

1. Krishna Kant, Computer-based Industrial Control, Prentice Hall, New Delhi, 1997.
2. Computer aided process control, S. K. Singh, PHI.

References:

1. Distributed computer control for industrial automation, Popovik, Bhatkar, Dekkar Pub.
2. Understanding Distributed Process Systems For Control, Samuel Herb, ISA.
3. B.G. Liptak, Process software and digital networks, CRC press, Florida.
4. Practical Distributed Control Systems for Engineers and Technicians-IDC TECHNOLOGIES

306270: Digital Signal Processing

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: Z-transforms and its properties, Fourier transforms and its properties.

Course Outcomes (COs): The students will be able to

1. Understand benefits and limitations of processing signals digitally
2. Recognize types of discrete-time signals and properties of discrete-time systems.
3. Compute the response of discrete-time systems to various input signals.
4. Evaluate and analyze the frequency domain characteristics of Discrete-Time Systems
5. Design and implement different frequency selective FIR and IIR filters.

Unit I: Introduction to Discrete Time Signals and Systems (07)

Basic elements of Digital Signal Processing (DSP), analog to digital conversion (ADC), comparison between DSP and Analog Signal Processing (ASP) with applications of DSP. Discrete-time signals and systems: classification of signals, sampling process/theorem, aliasing effect and reconstruction, classification of systems, input-output description of systems.

Unit II: Analysis of Discrete-Time Systems (07)

Linear convolution, causality and stability of discrete time systems, autocorrelation, cross-correlation, Z-transform and its properties, solving difference equations and analysis of discrete-time systems in Z-domain, transfer function, pole-zero plot. Block-diagram representation of discrete-time systems. Implementation of discrete-time systems: Structures for the realization, Finite Impulse Response (FIR) and Infinite Impulse Response (IIR) structures.

Unit III: Frequency analysis of Discrete-Time Signals (07)

Frequency response of LTI systems, ideal frequency selective filters, magnitude and phase response, Discrete-Time Fourier Series (DTFS), properties of DTFS, The Discrete Time Fourier Transform (DTFT), symmetry properties and theorems of DTFT. Energy density spectrum and power density spectrum.

Unit IV: Discrete Fourier Transform (DFT) (07)

Discrete Fourier transform (DFT), properties of DFT, symmetry properties, circular convolution, linear filtering methods based on DFT, Frequency analysis of signals using DFT, Efficient computation of DFT, Fast Fourier Transform (FFT) algorithms: Radix-2 Decimation-In-Time (DIT) and Decimation-In-Frequency (DIF)FFT algorithms.

Unit V: Design of digital IIR filters from analog filters (07)

Introduction to analog IIR filters, Butterworth approximation, Chebyshev approximation. Design of digital IIR filter: impulse invariance method, bilinear transformation, approximation derivative method. Frequency transformations in analog and digital domain.

Unit VI: Design of FIR filters (07)

Introduction to FIR filters, linear phase filters, symmetric and anti-symmetric filters, FIR design by Fourier approximation, window method, frequency sampling method, comparison between FIR and IIR filters.

List of Experiments:

Students are expected to perform minimum ten experiments:

1. Generate the discrete-time standard test signals viz. impulse, unit step, ramp, parabolic, exponential and sinusoidal signal.
2. Implement the basic operations on the given signals.
3. Implement Linear Convolution of the given two discrete time sequences.
4. Obtain the Auto-correlation and Cross-correlations of the given sequences.
5. Obtain the transfer function and plot is pole-zero plot in z-domain.
6. Find the DTFT of the given sequence and plot its magnitude and phase plot
7. Find the DFT of the given sequences. Plot its magnitude and phase plot. Also, find its IDFT to obtain the original sequence.
8. Implement the circular convolution of the given two sequences.
9. Obtain the linear convolution using circular convolution of two given sequences
10. Obtain the DFT of the given sequences using DIT-FFT algorithm and plot its magnitude and phase spectrum.
11. Obtain the DFT of the given sequences using DIF-FFT algorithm and plot its magnitude and phase spectrum.
12. Write a program to design and implement FIR filters using windowing method for the given specifications.
13. Write a Program to design and implement digital IIR filter using Butterworth approximations for the given specifications of a low-pass filter.
14. Write a Program to design and implement digital IIR filter using Chebyshev approximations for the given specifications of a low-pass filter.

Text Books:

1. Proakis J. G and D. G. Manolakis, "*Digital Signal processing, Principles, Algorithms and Applications*", Prentice Hall of India.
2. Johnson J. R, "*Introduction to Digital Signal Processing*", Prentice Hall of India.
3. Rabiner, Gold, "*Theory and Applications of Digital Signal Processing*", Tata McGraw Hill.
4. E. C. Ifeachor& B. W. Jarvis, "*Digital Signal Processing- A Practical Approach*", Pearson Education,New Delhi

References:

1. S. K. Mitra, "*Digital Signal Processing: A Computer based Approach*", Tata McGraw Hill.
2. Oppenheim A. V and R. W. Schafer, "*Discrete Time Signal Processing*", Pearson Education, India,New Delhi.

306271 A: Elective II A: Building Automation

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: 25 Marks	

Course Outcomes (COs): The students will be able to

1. Articulate the purpose and operation of HVAC system components, the operation of HVAC systems.
2. Apply knowledge of thermal comfort conditions and its impact on human comfort, productivity, And health.
3. Investigate HVAC air systems and water system operations and control philosophies
4. Evaluate importance of fire safety systems
5. Demonstrate the security & access control system.

Unit I: Introduction to Building Automation Systems (06)

- Intelligent building and it's architecture
- Evolution of intelligent buildings & Lifecycle of buildings
- Different systems in BAS which includes HVAC, security, fire, lighting systems. Importance of each system in BAS.
- BAS System Hierarchy –Field level components, Direct Digital Control (DDC), Supervisory Controller, Server, Operator Workstation (OWS)
- BAS communication protocols and addressing concepts – BACnet and LON

Unit II: Comfort parameters and measurement in BAS system (06)

- Comfort parameters for human being- temperature, humidity, flow, pressure, clean air
- Working Principle, Characteristics of different types of temperature sensors- RTD, Thermistor, Thermocouple, Bimetallic strip
- Humidity, Specific Humidity, Relative Humidity, Dew point, Saturation point
- Dry bulb & Wet bulb temperature, Working principle of Psychrometer
- Pressure and Flow measurements in HVAC for air-side and water-side applications
- Measurement of CO2 level in air, Air filtration techniques, ozonisation and UV
- Other Parameters affecting building operation- Building load for Chilled water and hot water system, Working principal of BTU meter, BTU meter mounting.

Unit III: HVAC Air Systems - Air handling unit (AHU) & Terminal Units (VAV) (07)

- Concept of Air handling unit. Design, working of different components in AHU - damper, filter, cooling coil, heating coil, fan, heat recovery wheel, humidifier.
- Design and working of different types of AHU with combination of- 100% outdoor air, mixed air, constant volume, variable volume, dual duct, single duct.
- Operation of different modes in AHU- cooling, heating, humidification,

dehumidification, static pressure control, volume matching, economizer mode.

- Heat recovery techniques- plate heat exchanger, heat recovery wheel and glycol heat recovery loop.
- Concept of Variable Air Volume (VAV) system-Design, working, use of different types of VAV- CAV, cooling only, with reheat, supply-exhaust VAV for critical areas (hospital and labs)

Unit IV: HVAC Water Systems (07)

Chilled Water Systems:

- Concept of refrigeration cycle. Working, mechanical configuration of different types of components used in refrigeration cycle- evaporator, condenser, compressor, expansion valve. Difference between air-cooled chiller and water-cooled chiller. Working and mechanical configuration of different types of cooling towers. Concept and working of heat pump.
- Design, working of different types of chilled water system- single chiller system, series chiller system, parallel chiller system. Working of different components of chilled water system- decoupler line, bypass line, primary circuit, secondary circuit, and condenser pumps

Hot Water Systems:

- Working and design of different types of boilers- fire tube, water tube, packaged boiler.
- Working and design of different types of heat exchanger.
- Design of different types of hot water system- with boilers, heat exchanger with steam input, heat exchanger with hot water input
- Concept of geothermal system

Unit V: Introduction to Fire Alarm System & Fire Detection (07)

- What is Fire? Fire alarm System-The History
- FAS architecture & operation
- Classification of Fire Alarm System, Conventional and Addressable Fire Alarm System
- Important Codes-NFPA72, IS 2189, BS 5839
- Critical fire & safety parameters in Facility Environment
- FAS Loops-Classification of Loops and Examples
- Power Supply Requirement and its designing parameters. Battery Calculations.
- Network terminology for Fire Systems, Classification of Cables, Class of Cables, Types, and distance Supported specific to fire alarm system
- Working Principles of Fire Alarm devices and its working Application in building safety

- Components of fire detection system, SLC wiring and its classification

Unit VI: Introduction to Building Security – Access Control & CCTV (07)

- Basic Concept of Access Control System it's benefits & architecture
- Access Control System Devices –Its features and Working principles. Anti pass back, Forgiveness, Two-man Rule, Time and Attendance, Guard Tour, Elevator Control
- Secure and Non-Secure Concept
- Card Technology Overview –Smartcard, Proximity Card, MI fare Cards
- System Architecture of Access Control System
- Basic of CCTV system, System Architecture of CCTV System
- Types of Camera –Fixed, PTZ, Analog, Digital
- Video Analytics, Camera Connectivity, Video Management System: DVR, DVM, NVR

List of Experiments:

Students are expected to perform minimum eight experiments:

1. To study Architecture of BMS & IBMS
2. To study Psychometric chart and various parameters
3. To study different types of Air Handling Units
4. To study various terminal unit systems (CAV, VAV)
5. To study Chilled Water System and loops
6. To study Hot Water System and loops
7. To study FAS loops and classifications
8. To study SLC wiring, loops, classifications
9. To study cause and effect matrix-Fire alarm system
10. To study CCTV System Architecture and types of cameras

Text Books:

1. HVAC Systems Design Handbook, Fifth Edition by Roger W. Haines
2. HVAC Fundamentals, volume 1 to 3 by James E. Brumbaugh
3. Basics of Air Conditioning by ISHRAE. Indian Society of Heating, Refrigerating &
4. Air Conditioning Engineers (product code: B0004 for online shopping)
5. Fire Alarm and Detection System: Quick Book by A. Bhatia

References:

1. All About AHU's by ISHRAE. Indian Society of Heating, Refrigerating & Air Conditioning Engineers (product code: B0005 for online shopping)
2. Chillers Basics by ISHRAE. Indian Society of Heating, Refrigerating & Air Conditioning Engineers (product code: B0009 for online shopping)

306271 B: Elective II B: Machine Learning

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: 25 Marks	

Course Outcomes: On completion of the course, learner will be able to–

1. Demonstrate machine leaning and its life cycle.
2. Apply regression analysis of machine learning.
3. Explain classification of supervised machine learning.
4. Demonstrate supervised machine learning.
5. Apply extended methods of supervised machine learning.
6. Demonstrate unsupervised machine learning.

Unit I: Introduction to Machine Learning and its Life Cycle (07)

Need For Machine Learning, What Is Machine Learning, Machine Learning Definitions, Machine Learning Life cycle, Types Of Machine Learning, Type Of Problems Solved Using Machine Learning, Job Roles in Machine Learning, Applications of Machine Learning

Unit II: Supervised Learning: Regression Analysis (07)

Assumption of Regression, Simple Linear Regression, Multiple Linear Regressions , coefficient, intercept, ordinary least square method, best fit line, model evaluation

Unit III: Supervised Machine Learning: Probability Analysis (07)

Introduction to Logistic Regression , Probability, Odd Ratio, Sigmoid/Logic function ,
Introduction to KNN: Lazy Learner, Distance Metrics and evaluation of KNN Model
Introduction to Naïve Bayes: Conditional Probability, Bayes Thereom, Naïve Bayes.

Unit IV: Support Vector Machine (07)

Introduction to SVM, Support Vectors, Margin , Hyperplane, Hard Margin and soft Margin, Linear separable data and non linear separable data, Kernels.

Unit V: Supervised Machine Learning: Classification Analysis (07)

Introduction to Decision Tree: Terminology: Root node, leaf node, edges, Tree split criteria, Gin index , entropy, chi square test, pruning. Introduction to Random Forest: Ensemble learning of decision tree. Model Performance and Measure (Evaluation Metrics) Evaluation Metrics, over fitting and under fitting Regularization, Ensemble Learning, Model Hyper parameter tuning

Unit VI: Unsupervised Machine Learning: Cluttering (07)

Introduction to K Means Clustering, Centroid calculation, Distance measures, Elbow method, silhouette method, Hirarchical clustering, Model evaluation .

List of Experiments:

Students are expected to perform minimum eight experiments:

1. Home price prediction using machine learning
2. Passenger survival prediction using classification techniques
3. Students performance analysis using regression technique
4. Movie Award Analysis
5. Iris Flower species prediction using Machine Learning
6. Loan Prediction Analysis
7. Cancer prediction analysis using Machine Learning
8. Advanced Home price prediction using Machine Learning
9. Case study on Tableau Dashboard

Text Books:

1. Machine Learning For Absolute Beginners by Oliver Theobald
2. Python Machine Learning by Sebastian Raschka and Vahid Mirjalili
3. Understanding Machine Learning by Shai Shalev-Shwartz and Shai Ben-David

References:

1. Introduction to Machine Learning with Python by Andreas C. Müller, Sarah Guido
2. Machine Learning For Dummies by John Paul Mueller and Luca Massaron
   Fundamentals of Machine Learning for Predictive Data Analytics: Algorithms, Worked Examples, and Case Studies by John D. Kelleher, Brian Mac Namee, and Aoife D'Arcy

306271 C: Elective II C: Electrical Drives

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: 25 Marks	

Prerequisites: The students should be conversant with basic electrical concepts, basic electronics concepts and electrical and electronic components.

Course Outcomes (COs): The students will be able to learn

1. Select a drive for a particular application based on power rating.
2. Select a drive based on mechanical characteristics for a particular drive application.
3. Operate and maintain solid state drives for speed control of DC and AC machines.
4. Operate and maintain solid state drives for speed control of various special electrical machines
5. Understand different PWM techniques.

Unit I: Introduction (05)

History of DC Drive -Electronic Control -Solid State Control, State of Art of DC Drive, Block Diagram of Drive - Part of Electrical Drive, Applications in different domains.

Unit II: Basics of Electrical Drives (06)

Terminology used in Drives and controls system, Types of Load-Quadratal diagram of speed, torque characteristics, Types and Characteristics of load torque, Dynamics of motor, load combination, steady state & transient stability of an electrical drive, Determination of moment of inertia.

Unit III: Converters and Control (05)

Phase controlled converters, four quadrant operations, Choppers, AC to DC converters, Inverters and PWM Techniques.

Unit IV: DC Motor Drives (08)

Speed-torque characteristics DC shunt, PMDC and series motors, Block diagram and flow of control signals, Speed and torque control methods, Field weakening control, Selection of Drives for different application and environment, Use of programming software to configure DC Drive, Parameterization of Drive for given assignments.

Unit V: AC Motor Drives (08)

Speed-Torque characteristics of induction motor, V/F control method, Vector control method, Vector control with sensor, Selection of Drives for different application and environment, Synchronous Servo motor and drive-Introduction, Speed and position control methods of servo motor & Servo Drive, Use of programming software to configure AC drive, Parameterization of Drive for given assignments

Unit VI: Applications of Electric Drives (08)

Introduction to Solar and battery powered Drives Siemens- Sinamics V20, Introduction to traction Drives, Servo motor drive requirement – control and implementation traverse application.

List of Experiments:

Students are expected to perform minimum eight experiments:

1. To study the fundamental and block diagram of Electric drive.
2. To study different methods of speed control of D.C. Motor & AC Motor
3. Configuring DC drive & Quick commissioning of DC motor and its optimisation.
4. Configure control of D.C. motor for (a) Current limit control (b) Closed loop torque control(c) Closed loop speed control.
5. Configure braking control of D.C. Motor using 4Q-DC drive.(OFF1,OFF2,OFF3, DBR)
6. To study different methods of Starting of A.C. Motor & Speed Control.
7. To study and configure AC drive for quick commissioning of AC motor with V/F based speed & Vector control method with Its optimisation & observe difference.
8. Configure drive for different DI/DO and AI/AO, & Scaling of AI /AO as per assignment
9. Configure braking control of A.C. Motor using AC drive.(OFF1,OFF2,OFF3, DBR)
10. Configure drive for HVAC temperature control of room using PID control & digital IO's.
11. Configure drive for Staging & de-staging application for multiple pumps to maintain constant pressure in line
12. Configure Servo drive, motor and simulate speed control of Servo motor.
13. Configure Servo drive, motor and simulate position control of Servo motor. (relative & Absolute)

Text Books:

1. Power Electronics by M. H. Rashid 2nd Edition, PHI.
2. Power Electronics by P. C. Sen, THM.

G. K. Dubey, Fundamentals of Electrical Drives,Narosa-1995.

References:

1. R. Krishnan, Electrical Motor drives, PHI.
2. G. K. Dubey, Power Semiconductor controlled drives, Prentice hall-1989.
3. W. Leohnard ,Control of Electric Drives,Springer-2001.

306271 D: Elective II D: Analytical 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: 25 Marks	

Course Outcomes: On completion of the course, learner will be able to–

1. Able to describe working of Different analyzers
2. Able to analysis and explain working of all types of spectrometers
3. Able to recommend appropriate analytical method/instrumentation for a particular application.

Unit I : **Introduction (07)**

A. Introduction to Chemical Instrumental Analysis, Advantages over classical methods, classification, various units used in chemical analysis.

B. Electro-magnetic spectrum, Light sources and Sensors & Detectors: Light sources, Photomultipliers, Electron Capture Detector (ECD), Thermal Conductivity Detectors, Electrochemical Flame Ionization Detector (FID), etc

Unit II : Spectrometric Methods (07)

Laws of Photometry, Absorption Spectrophotometers : UV, VIS spectrophotometers – single beam and double beam instruments, Instrumentation associated with the above spectrophoto meters, Sources and detectors, Emission Spectro-photo meters: Flame emission and atomic absorption spectrophotometer, Atomic emission spectrophotometer, Scientific and Industrial applications.

Unit III : Gas and Liquid Chromatographs (07)

Basic principle of gas chromatography, Liquid chromatography, HPLC different types of columns, Detectors, Recorders and associated equipment, Detectors used and Applications of chromatography.

Unit IV: Analysers (07)

Flue gas analysis using thermal conductivity principle, Oxygen analysers using paramagnetic principle, Zirconium oxide cells, Pollution Monitoring Instruments. CO monitors – NOx analyser – H2S analyser system – Industrial analyzers. Turbidity Analyzers, Industrial applications.

Unit V: Separation Methods (07)

A. Membrane separation process: Operating principles and applications, microfiltration, ultra filtration, reverse osmosis, dialysis and electro dialysis. Applications.

B. Mass Spectrometer (MS): Principle, ionisation methods, mass analyzer types – magnetic deflection type time of flight, quadrupole, double focusing, and detectors for MS. Applications.

Unit VI : Radioactive Instrumentation (07)

Nuclear Radiation Detectors, GM counter, Scintillation counter, Ionization chamber– Solid state detector, Gamma Spectrometry, Industrial application of radiation measurement.

List of Experiments:

Students are expected to perform minimum eight experiments:

1. Study of Photomultiplier tube.
2. Study of filter photometer.
3. Study of flame photometer.
4. Study of Reverse Osmosis.
5. Study of UV-visible spectrophotometer.
6. Study of Air Quality Monitoring Systems.
7. Study of Gas Chromatograph.
8. Study of Atomic Absorption Spectrophotometer.
9. Study of Turbidity Analyzers
10. Study of Flue Gas analyzers.

Text Books:

1. Instrumental Methods of Analysis, Willard, Merritt, Dean, Settle, CBS Publishers & Distributors, New Delhi, Seventh edition.
2. Handbook of Analytical Instruments, 2nd edition, Khandpur R.S
3. Instrumental Methods of Chemical Analysis, Galen W. Ewing, McGraw-Hill Book Company, Fifth edition

References:

1. Analytical Instrumentation by Bela G. Liptak, 1St edition, 1994
2. Introduction to Instrumental Analysis, Robert D. Braun, McGraw-Hill Book Company.
3. Principles of Instrumental Analysis, Skoog, Holler, Nieman, Saunders College Publishing, 1998.

306272: Mini Project

Teaching Scheme:	Examination Scheme:	Credits:
Practical: 2 Hrs/ Week	Term- Work : 25 marks	Term Work: 1

Course Objectives:

- To undertake & execute a Mini Project through a group of students.
- To understand the "Product Development Cycle", through Mini Project.
- To plan for various activities of the project and distribute the work amongst team members.
- To learn budget planning for the project.
- To inculcate electronic hardware implementation skills by –
    - **a.** Learning PCB artwork design using an appropriate EDA tool.
    - **b.** Imbibing good soldering and effective trouble-shooting practices.
    - **c.** Following correct grounding and shielding practices.
    - **d.** Knowing the significance of aesthetics & ergonomics while designing electronic product.
- To develop students abilities to transmit technical information clearly and test the same by delivery of Seminar based on the Mini Project.
- To understand the importance of document design by compiling Technical Report on the Mini Project work carried out.

Course Outcomes:

The student will be able to

- Planning and implementation of hardware/ software project .
- Prepare the budget for hardware requirement .
- Demonstrate the project .
- Work as a team member.

Maximum Group Size:

Minimum 2 and maximum 3 students can form a group for the mini project.

Project Type:

The selected mini project must be based on development of a prototype electronic system/product mandatorily having a hardware component with supporting software.

The Assessment Scheme will be:

a. **Continuous Assessment 15 marks** *(based on regular interaction, circuit development)*

b. **End Semester 10 marks** *(based on implementation, testing, results, poster presentation, and demonstration)*

Execution steps for Mini Projects:

1. Complete Paper work Design using datasheets specifying:
    a. Selection criteria of the components to be used.
    b. Specifications of system i/p and desired o/p.
    c. Module based hardware design.
    d. Test points at various stages in various modules
2. The circuit should be simulated using any of the standard simulation software available (either complete circuit to be simulated, if possible or an appropriate part of the circuit can be simulated).
3. Algorithm and the flow chart of the software part must be defined.
4. Result verification for hardware and testing the algorithms.
5. Comparison with the paper design to identify the discrepancies, if any. Justification of the same must be given.
6. Verified circuit should be assembled and tested on breadboard or general purpose board.
7. Simulation results and/or the snapshots indicating the current and voltage readings or detailing the test point results at various stages must be preserved and included in the project report.
8. Art work / layout of the circuit using standard layout tools.
9. Assembling and testing of circuit on final PCB.
10. Design and fabrication of suitable enclosure and outside fittings such as switches, Buttons, knobs, meters, indicators, displays etc.
11. Final testing of the circuit using the earlier defined test points.
12. Preparing Bill of components and materials.
13. Drawing entire circuit diagram (component level), outlining various blocks indicating test points, inputs and outputs at various stages on A3 graph sheet.

Domains for projects may be from the following, but not limited to:

- Instrumentation and Control Systems
- Electronic Systems
- Biomedical Electronics
- Power Electronics
- Embedded Systems
- Mechatronic Systems
- Agriculture Instrumentation.

A project report with following contents shall be prepared:

- Title
- Specifications
- Block diagram
- Circuit diagram
- Selection of components
- Simulation results
- PCB artwork
- Layout versus schematic verification report
- Testing procedures
- Enclosure design
- Test results
- Conclusion

306273: Internship

Teaching Scheme:	Examination Scheme:	Credits:
Practical: 4 Hrs/ Week	Term- Work: 100 marks	Term Work: 4

Course Outcomes (COs): The students will be able to learn

1. Develop professional competence through industry internship
2. Apply academic knowledge in a personal and professional environment
3. Build the professional network and expose students to future employees
4. Apply professional and societal ethics in their day-to-day life
5. Develop professional approach for social, economic, and administrative considerations.

Guidelines

Engineering internships are intended to provide students with an opportunity to apply theoretical knowledge from academics to the realities of the field work/training. With reference to AICTE policy the following guidelines are proposed to give academic credit for the internship undergone as a part of the TE curriculum.

Formation of internship coordination team:

- Department should appoint an internship coordination team. Team should make efforts to fetch various internship opportunities for students and make sure that every student has got an internship. Batch-wise faculty Supervisors/Mentors should be allocated to monitor and keep track of their progress at their internship provider's end through time-to-time communication and meetings.
- Even though SPPU structure shows 4 hours/week, looking at travelling and other parameters, it is recommended that one complete day may be assigned in their class timetable for the complete semester assigned to part time internship work.

Internship work Identification:

Contacting various companies for Internship and Internship work identification process should be initiated in the Vth semester in coordination with training and placement cell, industry institute cell, internship cell etc. This will help students to start their internship work on time. Also, it will allow students to work in vacation period after their Vth semester examination.

Student can take internship work in the form of Online/onsite work from any of the following but not limited to:

- Industry / Government Organization Internship
- Internshala
- Online internship Amazon, Google, Microsoft etc.
- EDC Cell and startups cells of institute / In-house product development, intercollegiate, inter department research internship under research lab/group,

micro/small/medium enterprise/online internship.

- Research internship under professors, IISC, IIT's, Research organizations
- NGOs or Social Internships, rural internship
- Participate in open source contribution
- Student training combined by industry and academia

Internship work Allocation:

- List of the student's name, internship provider and faculty mentor should be made readily available by the internship coordination team. After getting the list, immediately, the first meeting should be conducted between student, internship provider and faculty mentor to finalize the scope of the work and feasibility study.
- Within the first month after allocation of internship written Internship Plan should be submitted to the internship coordination team. Refer Appendix III for format of the Internship Plan.

  Note: Required procedure like MoU, student deputation letter, NoC for association between internship provider and institute can be completed as per mutual understanding in required and necessary format.

Internship progress Monitoring:

- Every student is required to prepare an individual file containing documentary proofs of the activities done by him.
- There should be at least bimonthly meetings between faculty mentors, internship providers and students to track and discuss the progress and record of the same should be maintained by the student in his/her individual internship log book.

Sr. no	Date	Work done	Remark by internship external mentor with signature	Remark by internship internal mentor with signature

Internship Work Evaluation:

Internship work evaluation will be done jointly by internal and external mentors. 4 credits (100 Marks) are assigned for semester long internship work. Continuous assessment report/meetings/log book/work report should carry 2 credits and final presentation along with report should carry 2 credits.

Following evaluation parameters can be used for Continuous Evaluation (2 credits/50 Marks)

- Technical Knowledge
- Communication & Presentation Skills
- Teamwork
- Creativity
- Planning & Organizational skills
- Adaptability
- Analytical Skills

- Attitude & Behavior at work
- Societal Understanding
- Ethics
- Regularity and punctuality
- Attendance record
- Logbook

Final evaluation will be based on the following criteria (2 credits/50 Marks)

Roll no	Name of the student	Title	Final evaluation			Total (50)
			Report (15)	Presentation (15)	Oral (20)	

The internship report should cover the following aspects:

- Title
- Introduction
- Problem statement
- Objectives
- Scope and rationale of the study
- Methodological details
- Results / Analysis and conclusion
- Log book of work
- Acknowledgement
- Internship completion certificate.

406274: Audit Course-VI

The student have to opt for one of the audit courses per 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. 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.

(Ref-http://www.unipune.ac.in/Syllabi_PDF/revised-2015/engineering/UG_RULE_REGULATIONS_FOR_CREDIT_SYSTEM-2015_18June.pdf)

Guidelines for Conduction and Assessment (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 Guidelines for Assessment (Any one or more of following but not limited to)
- Written Test
- Demonstrations/ Practical Test
- Presentations
- IPR/Publication

Audit courses suggested by BoS, Instrumentation Engineering:

1. Engineering Management

2. Principles of Management

3. Project Management for Engineers

4. Business Ethics.