Course Objective:

- To understand the advanced concepts in Linear Algebra
- To introduce the linear, dynamic and integer programming concepts in operations research

Course Outcomes

CO1: Understand the basic concepts of vector spaces, subspaces, linear independence, span, basis and dimension and analyze such properties on the given set.

CO2: Understand the concept of inner products and apply it to define the notion of length, distance, angle, orthogonality, orthogonal complement, orthogonal projection, orthonormalization and apply these ideas to obtain least square solution.

CO3: Understand the concept of linear transformations, the relation between matrices and linear transformations, kernel, range and apply it to change the basis, to get the QR decomposition, and to transform the given matrix to diagonal/Jordan canonical form.

CO4: Apply different types of Optimization Techniques in engineering problems.

Linear Algebra, Eigen values and vectors, Singular Value Decomposition

Vector Spaces: General vector spaces - Sub spaces - Linear independence - Basis – Dimension Row space, Column space and Null Space, Eigen values and Eigen vectors.


Operations Research

Linear Programming models, simplex search, sensitivity analysis, artificial standing solutions, duality & sensitivity in linear programming, economic interpretations, integer programming, dynamic programming

TEXT BOOKS/ REFERENCES

Course Objective:
- To introduce the architecture of computer controlled industrial systems
- To provide an overview of various bus standards and protocols

Course Outcomes

CO1: Understand the architecture of computer based industrial automation systems
CO2: Identify the various communication protocols for industrial networks
CO3: Apply real time programming for distributed control systems
CO4: Design applications of computer based industrial control


Real-time Programming: Introduction to Real-time operating system, Multi-tasking, task management, inter-task communications, RTOS tasks-RTOS scheduling– Interrupt processing-Synchronization-Control blocks-Memory requirements, Real-time programming languages, Personal computer in Real-time Environment: PC bus and signals, Interrupts, Interfacing PC to outside world, Industrial Personal Computer development, PC based distributed control systems Modeling and simulation for Plant Automation, Industrial Control Applications: Model based controllers, predictive control, Artificial Intelligent based systems – case studies

TEXT BOOKS/ REFERENCES
5. User Manuals of Foundation Field bus, Profibus, Modbus, Ethernet, Device net, and Control net.
ADVANCED CONTROL SYSTEM

Course Objective:
- To analyze the LTI system in a state space framework.
- To design a state feedback controller and state observer.
- To understand and analyze the behavior of nonlinear systems.
- To gain an idea about the adaptive controllers and its applications.

Course Outcomes

CO1: Analyse linear system in state space approach
CO2: Design state feedback controller, observer and optimal controller for linear systems
CO3: Analyse non-linear system characteristics and its stability
CO4: Execute adaptive control techniques and parameter estimation of dynamic systems

Review: Concept of state, state variables and state model, Control system design in state space: concept of controllability and observability, pole placement techniques design using state feedback, design of state observers, Design of regulator systems with observer, Design of control systems with observer, Quadratic optimal regulator systems, Non-linear systems: Introduction, behavior of non-linear system, common physical non-linearity saturation, friction, backlash, dead zone, relay, multi-variable non-linearity. Phase plane method, singular points, stability of nonlinear system, limit cycles, construction of phase trajectories. Liapunov stability criteria, Liapunov functions, direct method of Liapunov and the linear system, Hurwitz criterion and Liapunov’s direct method, construction of Liapunov functions for nonlinear system. Adaptive control : Closed loop and open loop adaptive control. Self-tuning controller, parameter estimation using least square and recursive least square techniques, gain scheduling, model reference adaptive systems (MRAS), self-tuning regulators.

TEXT BOOKS/ REFERENCES

Course Objective:
- To comprehend the process of data handling through data preprocessing and data analysis
- To provide insight into data visualization methods

Course Outcomes
- CO1: Understand the different matrix decomposition and statistical modelling techniques
- CO2: Apply various data preprocessing techniques to perform feature selection
- CO3: Analyze the data using the evaluation metrics
- CO4: Examine the processed data through clustering techniques


TEXT BOOKS/ REFERENCES
EMBEDDED SYSTEM DESIGN  3 0 0 3

Course Objective:
- To introduce Embedded system principles and programming concepts
- To expose the concepts of microcontroller based system integration and interfacing by introducing ARM architecture.

Course Outcomes
- CO1: Understand the terminologies and characteristics of basic embedded systems
- CO2: Apply modelling and programming concepts for embedded product development
- CO3: Examine different interfacing techniques to communication with embedded hardware
- CO4: Investigate case studies in industrial embedded systems

Introduction to Embedded systems, Characteristics and quality attributes (Design Metric) of embedded system, hardware/software co-design, Embedded micro controller cores, embedded memories, Embedded Product development life cycle, Program modeling concepts: DFG, FSM, Petri-net, UML. Embedded C-programming concepts, Basic embedded C programs/applications for ARM-v7, Interfacing and Integration of microcontroller based systems, communication protocols like SPI, SCI (RS232, RS485), I2C, CAN, USB (v2.0), fundamentals of wireless networks for embedded system - Bluetooth, Zig-Bee. Examples of Industrial process automation, software development using python, Introduction to Linux OS, Rapid prototyping using low cost hardware (STM32 discovery board, Raspberry Pi)

TEXT BOOKS/ REFERENCES

MODELING AND SIMULATION LAB  0 0 1 1

Course Objective:
- To equip students with skills in various packages like MATLAB, LABVIEW, etc. and to give exposure in implementation of Digital control system techniques

Course Outcomes
- CO1: Model dynamic systems using MATLAB/LABVIEW
- CO2: Develop microcontroller-based system interface
- CO3: Design Data Acquisition systems using LABVIEW

Modeling and analysis of dynamic systems using MATLAB/LABVIEW software, Microcontroller based
system interfacing, LABVIEW based Data Acquisition Systems, Interfacing PC with Real-time systems

ARCHITECTURE OF INTELLIGENT SYSTEMS

Course Objective:
- To provide the fundamental concepts of expert systems
- To introduce algorithms for developing agent-based architectures

Course Outcomes
- CO1: Understand the characteristics of knowledge base systems
- CO2: Apply the object-oriented concepts in intelligent systems
- CO3: Identify the characteristics and architectures of multi agent systems
- CO4: Implement different algorithms for multi-agent systems

Knowledge-based systems, Expert systems, Knowledge acquisition, Computational intelligence, Rule-based systems, Forward-chaining (a data-driven strategy), Conflict resolution, Backward-chaining (a goal-driven strategy), Sources of uncertainty, Bayesian updating, Certainty theory, Possibility theory: fuzzy sets and fuzzy logic, Object-oriented systems, Data abstraction, Inheritance, Encapsulation, Unified Modeling Language (UML), Dynamic (or late) binding. Intelligent agents - Characteristics of an intelligent agent, Agent architectures, Multiagent systems, Symbolic learning, Learning by induction, Case-based reasoning (CBR), Hill-climbing and gradient descent algorithms, Simulated annealing, Genetic algorithms, Systems for interpretation and diagnosis, Systems for design and selection, Systems for control, Hybrid intelligent systems, application based case studies.

TEXT BOOKS/ REFERENCES
Course Objective:
- To provide a probabilistic learning approach for data analysis
- To introduce basic machine learning algorithms with case studies

Course Outcomes
- CO1: Understand the basic terminologies in machine learning
- CO2: Apply the probabilistic approach for feature analysis
- CO3: Implement the different regression algorithms
- CO4: Design the applications of ensemble methods


TEXT BOOKS/ REFERENCES
FAULT DETECTION AND DIAGNOSIS

Course Objective:
- To provide insight into the signal processing techniques for fault handling
- To expose different fault diagnosis procedures through case studies

Course Outcomes
- CO1: Comprehend the basic terminologies in fault modelling
- CO2: Interpret different signal types in fault models
- CO3: Identify diverse fault detection and diagnosis methods
- CO4: Apply fault detection, diagnosis and tolerant methods in real time applications


TEXT BOOKS/ REFERENCES

INDUSTRIAL ELECTRONICS LABORATORY

Course Objective:
- To expose students to PLCs, HIL, SIL etc. in realizing industrial system prototypes.

Course Outcomes
- CO1: Implement data logging for real time systems
- CO2: Develop microcontroller-based closed loop control system
- CO3: Implement HIL/SIL/PIL for real time industrial applications

Data Loggers / Data Acquisition Systems, Programmable Logic Controllers for real-time systems, Micro
controller based closed loop control, Study of Hardware-in-loop/Software-in-loop/Processor-in-loop

RESEARCH METHODOLOGY

Course Objective:

- To familiarize with modeling, referencing, literature survey, etc
- To design experiments and to analyse results of the experiments
- To prepare technical reports and research papers
- To prepare material for technical presentation and do oral presentation
- To understand the purpose and terms of IPR
- To orient to ethics in research and publication

Course Outcomes

CO1: Understand types and methods of research, modeling, referencing, etc.
CO2: Able to design experiments and analyse results
CO3: Prepare and present research papers
CO4: Aware of IPR and ethics


Unit II: Problem Formulation, Understanding Modeling & Simulation, Conducting Literature Review, Referencing, Information Sources, Information Retrieval, Role of libraries in Information Retrieval, Tools for identifying literatures, Indexing and abstracting services, Citation indexes

Unit III: Experimental Research: Cause effect relationship, Development of Hypothesis, Measurement Systems Analysis, Error Propagation, Validity of experiments, Statistical Design of Experiments, Field Experiments, Data/Variable Types & Classification, Data collection, Numerical and Graphical Data Analysis: Sampling, Observation, Surveys, Inferential Statistics, and Interpretation of Results

Unit IV: Preparation of Dissertation and Research Papers, Tables and illustrations, Guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript. References, Citation and listing system of documents


TEXT BOOKS/ REFERENCES

INDUSTRIAL IOT  3 0 0 3

Course Objective:
- To impart the knowledge about various enabling technologies for IIoT, that links the automation system with enterprise, planning and product lifecycle.

Course Outcomes
- CO1: Understand the key techniques and theory behind Industrial Internet of Things
- CO2: Apply effectively the various enabling technologies (both hardware and software) for IIoT
- CO3: Carry out the integration of Cloud and IoT, Edge and Fog Computing
- CO4: Apply various techniques for Data Accumulation, Storage and Analytics
- CO5: Design and build IIoT system for any one interesting Use case


UNIT II: Data Analytics in IIoT : Introduction, Big Data Analytics, Machine Learning, Artificial Intelligence and Data Science-R and Python Programming, Data management with Hadoop, Data Center Networks, Edge / Fog Computing, Cloud Computing in IIoT, Augmented Reality and Virtual Reality, Cyber security in Industry 4.0.

UNIT III: IIoT Application Domains: Factories and Assembly Line, Food Industry. Healthcare, Power Plants, Inventory Management & Quality Control, Plant Safety and Security (Including AR and VR safety applications), Facility Management, Oil, chemical and pharmaceutical industry, Case Study: Applications of UAVs in Industries, Cyber Security in Industry 4.0

TEXT BOOKS/ REFERENCES
1. Antonio Capasso, Giacomo Veneri, "Hands-On Industrial Internet of Things", Packt Publishing, 2018
REAL TIME OPERATING SYSTEMS

Course Objective:
- To introduce the characteristics of Real-time operating systems
- To familiarize the function of RTOS kernels and its application domains

Course Outcomes

CO1: Understand the basic concepts in real time systems.
CO2: Identify various services provided by the RTOS Kernel
CO3: Develop various real-time scheduling algorithms for uni and multi-processor systems
CO4: Analyze the schedulability of task sets using different tests and discuss blocking and priority inversion in real time systems
CO5: Design and develop real time applications using RTOS

Introduction to Real–time Systems and Real Time Operating System Basics: real–time systems characteristics, RTOS Vs General–purpose OS, RTOS characteristics, existing RTOS category, kernel architecture, functions of RTOS kernel. Introducing tasks for concurrency: Task management, process, thread and task, task– basic notation in RTOS, task classification, task configurations, writing re–entrant codes, scheduling policies. Inter task communication: with and without resource sharing, shared memory, message and message queues, inter–task communication via message queues, inter–task communication models, need for synchronization, semaphores–binary and counting semaphores, inheritance, inversion, ceiling, deadlocks and starvation, priority inversion and mutexes. Clocks in distributed RTS, timers and timer ticks, clock synchronization, watch dog timer, relative and absolute timer, interrupts– ISR under RTOS, ISR to task communication, memory/ device I/O management. Study of RTOS– VX Works and μCoS, Introduction to POSIX and OSEK standards. Embedded RTOS, RTOS for fault tolerant applications

TEXT BOOKS/ REFERENCES
Course Objective:
- To expose the students to different sensors, transducers with signal processing circuits and communication technologies

Course Outcomes
- CO1: Understand the basic physical measurements
- CO2: Identify the different sensors and explain the operation
- CO3: Design signal conditioning circuits for the sensor measurements
- CO4: Identify smart sensors and its communication technologies

Sensor fundamentals-Uncertainty aspects, Mechanical transducers: pressure measurement- diaphragms; force measurement, cantilever beams; torque measurement, strain gauge. Vibration measurement. Passive electrical transducers: Resistive, thermal radiation detectors, hotwire resistance, resistive displacement, resistive strain, resistive pressure, linear variable differential transformer. Active electrical transducers: Thermoelectric-thermocouples, RTD, piezoelectric, Hall Effect, digital displacement, photoelectric. Acoustic sensors SODAR LIDAR; Non-contact NDE devices

Signal processing-frequency domain; sensor signal noise reduction techniques, Signal processing circuits: oscillators, comparators, PLL detector, first and second order active electrical filters, Modulated signals, sampling circuits, encoders and decoders, D-A and A-D converters, voltage to frequency counters, digital multiplexers and demultiplexers sensor interface into a microprocessor, Smart sensors- mems, Communication Technologies: wired, wireless. RF -Zigbee, Bluetooth, WiFi, Ethernet, GSM, GPRS.

TEXT BOOKS/REFERENCES
Course Objective:
- To introduce the different data acquisition techniques and components
- To familiarize with basic nonlinear data converters

Course Outcomes
- CO1: Identify the components and characteristics for Data Acquisition systems
- CO2: Understand the construction and operation of different data converters
- CO3: Identify the types of non-linear data converters
- CO4: Select linear and non-linear data converters for real time applications


Overview of D/A converter, types and characteristics.


TEXT BOOKS/ REFERENCES
HARDWARE SOFTWARE CO-DESIGN

Course Objective:
- To introduce model based embedded system design
- To familiarize with the high level synthesis, verification and implementation

Course Outcomes
CO1: Understand various models of computation for embedded systems
CO2: Understand the architectural selection, partitioning, scheduling and communication for embedded systems
CO3: Apply the simulation, synthesis and verification for FPGA implementation
CO4: Realize the retargetable code generation through hardware implementation


TEXT BOOKS/ REFERENCES
RECONFIGURABLE COMPUTING

Course Objective:
- To provide an overview of reconfigurable computing architectures
- To familiarize with the design tools and languages used for reconfigurable computing

Course Outcomes
CO1: Understand computing models and basic concepts of Reconfigurable computing
CO2: Understand reconfigurable computing devices and architectures
CO3: Apply design tools and languages for RC application development
CO4: Familiar with Middleware, Fault tolerance, Partial reconfiguration, device characterization, etc.

General overview of computing models, Basic RC concepts, Performance, power, size, and other metrics, RC devices and architecture – fine grained and coarse grained, integration into traditional systems, FPGA computing platforms, Design tools and languages: HDLs, Synthesis, PAR, HLL and HLS, RC application development, domains and case studies, Special topics in RC: Middleware, Fault tolerance, Partial reconfiguration, device characterization.

TEXT BOOKS/ REFERENCES

DEEP LEARNING

Course Objective:
- To familiarize with the basic and advanced neural network models to solve industrial problems

Course Outcomes
CO1: Understand the basic terminologies in machine learning
CO2: Know the learning and forecasting methodologies in neural networks
CO3: Identify the neural models for deep learning
CO4: Apply deep learned models for real time industrial problems

TEXT BOOKS/ REFERENCES

INDUSTRIAL ROBOTICS  
3 0 0 3

Course Objective:
- To impart knowledge about design and control of industrial robots

Course Outcomes
- CO1: Understand the principle of operation of sensors and actuators used in robotics
- CO2: Develop the kinematic models of manipulators
- CO3: Implement algorithms in autonomous mobile robot path planning, localization and control
- CO4: Design of algorithms for various industrial robotics applications


TEXT BOOKS/ REFERENCES
Course Objective:
- To introduce the design parameters for Human Machine Interface
- To familiarize with the different interaction models

Course Outcomes
- CO1: Understand the fundamental approaches for HMI
- CO2: Identify the different interaction models for interfacing
- CO3: Familiar with the communication and collaboration models
- CO4: Apply HMI modeling for real time applications


TEXT BOOKS/ REFERENCES
ARTIFICIAL INTELLIGENCE IN SMART Grids

Course Objective:
- To familiarize the concepts of smart grid
- To explore AI applications in smart grids

Course Outcomes
- CO1: Understand the basics of power system management and its automation
- CO2: Familiar with the features of Smart grid
- CO3: Understand synchronized measurement and management systems
- CO4: Employ AI in real time smart grid applications


TEXT BOOKS/ REFERENCES
COMMUNICATION SYSTEMS FOR INDUSTRIAL NETWORKING  3 0 0 3

Course Objective:
- To introduce the basic terminologies in communication systems
- To familiarize with wired and wireless communication protocols for industrial networks

Course Outcomes
CO1: Understand the basic terminologies in communication systems
CO2: Understand the SCADA System Components and architectures in automation industries
CO3: Explain the concepts, design considerations and design rules of industrial Ethernet
CO4: Identify wireless communication protocols for industrial networking


Applications & case studies: Factory network, Transportation automation

TEXT BOOKS/ REFERENCES
Course Objective:
To impart knowledge in handling optimization problems through operations research techniques

Course Outcomes
- CO1: Understand decision-making in certainty/uncertainty conditions
- CO2: Formulate models and solve real-time problems
- CO3: Apply advanced operations research techniques to cater industrial requirements

Linear programming - Simplex method – Big M method – Two phase method cases - Goal programming. Duality, sensitivity analysis - Changes in right-hand side constants of constraints- changes in objective function co-efficient-adding a new constraints-adding a new variable.
Unconstrained nonlinear algorithms-Constrained algorithms- Separable programming -Quadratic programming-Geometric programming-Stochastic programming.

TEXT BOOKS/ REFERENCES
Course Objective:

- To introduce the foundational concepts and tenets of IIoT security by presenting real-world case studies, threat models, and reference architectures.
- To provide with techniques and methodologies of securing industrial systems.

Course Outcomes

CO1: Understand the key techniques and theory behind cyber security of industrial systems
CO2: Understand the security threat models and reference architectures for connected industrial systems
CO3: Apply the various techniques and methodologies for securing (both hardware and software) IIoT
CO4: Apply various techniques for risk assessment and threat modelling
CO5: Design and build secured industrial system for any one interesting Use case

UNIT 1: Overview of Industrial Systems: view function-monitor function-control function, Industrial control system architecture: PLC-HMI-SCADA-Distributed control system-Safety instrumented system, The Purdue model for Industrial control systems, Industrial control system communication media and protocols, IoT Protocols-and IoT Cloud Infrastructure.


Case Study: Identification and categorization of Industrial system and network assets – Risk Assessment – mitigation activities – security improvement cycle of any interesting Industrial IoT use case.

TEXT BOOKS/ REFERENCES

1. Pascal Ackerman, "Industrial Cyber security", Packt Publishing, 2017
2. Sravani Bhattacharjee, "Practical Industrial Internet of Things Security", Packt Publishing, 2018
Course Objective:
- To review the literature and formulate a research problem
- To develop skill in use of computational and analytical tools
- To carry out the investigation and analyse the observations
- To communicate the findings orally as well as in writing
- To familiarize with project management

Course Outcomes
- CO1: Understanding research methodology
- CO2: Project planning
- CO3: Skill in literature survey
- CO4: Knowledge of computational and analytical tools
- CO5: Technical communication skill

Each student should select and work on a topic related to his/her field of specialization during third semester under the supervision of a faculty member. By the end of the third semester he/she must prepare a report in the approved format and present it.

Course Objective:
- To review the literature and formulate a research problem
- To develop skill in use of computational and analytical tools
- To carry out the investigation and analyse the observations
- To communicate the findings orally as well as in writing
- To familiarize with project management

Course Outcomes
- CO1: Skill in project planning and management
- CO2: Domain knowledge
- CO3: Skill in use of tool
- CO4: Technical communication skill
- CO5: Comprehension

During fourth semester each student should work further on the topic of the minor project or a new topic under the supervision of a faculty member. By the end of fourth semester the student has to prepare a report in the approved format and present it. Finally there has to be a research paper published in a scopus indexed conference or journal with proper affiliation and approval from the department.