M. Tech.

in

INDUSTRIAL AUTOMATION

CURRICULUM

(For students admitted in 2020-21)
The total minimum credits for completing the M. Tech. programme in Industrial Automation is 64.

**SEMESTER I**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>MA 623</td>
<td>Applied Mathematics</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>IC 601</td>
<td>Measurements in Manufacturing and Process Industries</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>IC 603</td>
<td>Industrial Automation Systems</td>
<td>3</td>
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<tr>
<td>4</td>
<td>ELECTIVE 1</td>
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<tr>
<td>7</td>
<td>IC 607</td>
<td>Process Instrumentation and Automation Laboratory</td>
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**Total** 20

**SEMESTER II**

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<tbody>
<tr>
<td>1</td>
<td>IC 602</td>
<td>Industrial and Data Communications</td>
<td>3</td>
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<tr>
<td>2</td>
<td>IC 604</td>
<td>Electric Drives and Control</td>
<td>3</td>
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<tr>
<td>3</td>
<td>IC 606</td>
<td>Robotics in Industrial Automation</td>
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**Total** 20
### SEMESTER III

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### SEMESTER IV

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<td>IC 610</td>
<td>PROJECT WORK - PHASE II</td>
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### LIST OF ELECTIVES - SEMESTER I

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<tbody>
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<td>1.</td>
<td>IC 611</td>
<td>Artificial Intelligence in Industrial Automation</td>
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<tr>
<td>2.</td>
<td>IC 613</td>
<td>Cyber Security in Industrial Automation</td>
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<td>3.</td>
<td>IC 615</td>
<td>Embedded Systems</td>
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<td>IC 617</td>
<td>Intelligent Transportation Systems</td>
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<td>IC 619</td>
<td>Fluid Power Systems</td>
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<td>IC 621</td>
<td>Control Systems</td>
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<td>System Identification</td>
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<td>IC 612</td>
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<td>2.</td>
<td>IC 614</td>
<td>Computer Vision and Image Processing</td>
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<td>IC 616</td>
<td>Predictive Analytics</td>
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<td>IC 618</td>
<td>Wireless Sensor Networks</td>
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<td>5.</td>
<td>IC 620</td>
<td>Augmented Reality</td>
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<td>6.</td>
<td>IC 622</td>
<td>Network Control System</td>
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<td>IC 624</td>
<td>Modeling, Simulation and Analysis of Manufacturing Systems</td>
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<td>IC 626</td>
<td>Rapid Prototyping</td>
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**Course Learning Objectives**

1. To learn the concepts of probability and statistics to industrial automation engineering problems.
2. Familiar with reliability engineering theory in determining the reliability of the systems.
3. To predict the relationship between parameters through correlation and regression analysis.
4. Compute the reliability of the systems.

**Course Content**

Random variable – Two dimensional random variables – Standard probability distributions – Binomial, Poisson and Normal distributions - Moment generating function.

Special distributions – Uniform, Geometric, Exponential, Gamma, Weibull and Beta distributions – Mean, Variance, Raw moments from moment generating functions of respective distributions.

Sampling distributions – Confidence interval estimation of population parameters – Testing of hypotheses – Large sample tests for mean and proportion – t-test, F-test and Chi-square test.

Curve fitting - Method of least squares - Regression and correlation – Rank correlation – Multiple and partial correlation – Analysis of variance - One way and two way classifications


**Text Books**


**Reference Books**

Course Outcomes

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

1. apply standard and special probability distributions to automation engineering problems.
2. indicate data pictorially and numerically and analyze it.
3. employ sampling distributions in testing various hypotheses.
4. use t-test, F-test and Chi-square test in determining the validity of data.
Course Code: IC 601
Course Title: Measurement in Manufacturing and Process Industries
Number of Credits: 3
Course Type: Core

Course Learning Objectives

1. To expose the students to the importance of measurements in manufacturing and process industries.
2. To expose the students to various measurement techniques used for the measurement of physical variables in manufacturing industries.
3. To expose the students to various measurement techniques used for the measurement of physical variables in process industries.
4. To make the students knowledgeable in the design, installation and troubleshooting of the instruments used in manufacturing and process instruments.

Course Content


Temperature measurement - Introduction to temperature measurements, Thermocouple, Resistance Temperature Detector, Thermistor and its measuring circuits, Radiation pyrometers and thermal imaging.

Pressure measurement - Introduction, definition and units, Mechanical, Electro-mechanical and electronic pressure measuring instruments. Low pressure measurement. Pressure and temperature transmitters, Current to pneumatic and pneumatic to current converters.

Flow measurement - Introduction, definition and units, classification of flow meters, differential pressure and variable area flow meters, Positive displacement flow meters, Electro Magnetic flow meters. Hot wire anemometer, laser Doppler anemometer, ultrasonic, vortex and cross correlation flow meters, and measurement of mass flow rate.

Level measurement - Introduction, Differential pressure level detectors, Capacitance level sensor, Ultrasonic level detectors and Radar level transmitters and gauges. Design of transmitters, self-diagnostics, communication, and remote calibration.

Safety - Introduction, electrical hazards, hazardous areas and classification, non-hazardous areas, enclosures - National Electrical Manufacturers Association (NEMA) types, fuses and circuit breakers. Protection methods: Purging, explosion proofing and intrinsic safety. Study for choice of materials in application areas - with respect to temperature, pressure, and corrosion environments (interface) and fluid interface.
Text Books


Reference Books


Course Outcomes

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

1. study the characteristics and specification of instruments.
2. understand the sensors and transducers used in manufacturing industries like displacement, velocity, acceleration, force, torque and load.
3. gain knowledge of different temperature, pressure, flow and level measurement techniques used in process industries.
4. grasp the world class industrial safety aspects
Course Code : IC 603  
Course Title : Industrial Automation Systems  
Number of Credits : 3  
Course Type : Core

**Course Learning Objectives**
1. To introduce the importance of automation techniques manufacturing and process industries.
2. To impart the role of PLC in industry automation.
3. To expose to various control techniques employed in process automation.
4. To develop automation system for manufacturing and process industries.

**Course Content**

**Automation in Manufacturing Industries**
Introduction- Automation in production system, Principles and strategies of automation, Basic elements of an automated system, Advanced automation functions, Levels of automations, Automated flow lines and transfer mechanisms, Analysis of transfer lines without storage, Automated flow lines with storage buffers.

Material handling and identification technologies -Overview of material handling systems, Types of material handling equipment, Design of the system, Conveyor system, Automated guided vehicle system, Automated storage systems, Interfacing handling and storage with manufacturing, Overview of Automatic Identification Methods.

Automated Manufacturing Systems-Components, Classification and overview of manufacturing systems, Cellular manufacturing, Flexible manufacturing system(FMS), FMS and its planning and implementation, Automated assembly system – design and types of automated assembly systems, Analysis of multi station and single station assembly machine.

**Automation in Process Industries**
Introduction to computer based industrial automation- Direct Digital Control (DDC), Distributed Control System (DCS) and supervisory control and data acquisition (SCADA) based architectures. SCADA for process industries includes understanding of RTUs, Pumping stations, Evacuation processes, Mass Flow Meters and other flow meters, Leak-flow studies of pipelines, Transport Automation.

Programmable Logic Controller (PLC)- Block diagram of PLC, Programming languages of PLC, Basic instruction sets, Design of alarm and interlocks, Networking of PLC, Overview of safety of PLC with case studies. Process Safety Automation: Levels of process safety through use of PLCs, Integrating Process safety PLC and DCS, Application of international standards in process safety control.
Distributed Control System- Local Control Unit (LCU) architecture, LCU Process Interfacing Issues, Block diagram and Overview of different LCU security design approaches, Networking of DCS. Introduction to communication protocols- Profibus, Field bus, HART protocols. Data gathering, Data analytics, Real-time analysis of data stream from DCS, Historian build, Integration of business inputs with process data, Leveraging RTU (as different from PLCs and DCS)

**Text Books**


**Reference Books**

4. https://nptel.ac.in/syllabus/108108098/

**Course Outcomes**

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

1. familiar with various automation technologies in manufacturing and process industries.
2. understand various automation tools and methods in manufacturing industry.
3. implement various control and automation method in process industries.
4. familiar with various communication technologies in manufacturing and process industries.
Course Code : IC 607
Course Title : Process Instrumentation and Automation Laboratory
Number of Credits : 2
Course Type : Laboratory

Course Learning Objectives
1. Impart knowledge in transmitter design
2. Exposure to different PLC programming languages
3. Able to provide adequate knowledge in SCADA and DCS
4. Study of HART and Field bus protocol.

List of Experiments
1. Design and development of two wire temperature Transmitter
2. Design and development of IoT based transmitter
3. Cascade and feedback controller design for real time process trainer
4. Feed forward and ratio controller design for real time process trainer
5. Development of combinational and sequential logic application using minimum PLC languages
6. Development of Ladder logic programme for control of real time processes.
7. Development of SCADA for a control of real time processes.
8. Study of HART and Field bus protocol
9. P&I diagram development using simulation software for complex processes
10. Study of Distributed Control System and different instruction sets.
11. Development of Cascade, ratio and feedback controller using DCS simulation software
12. Development of HMI and annunciator circuits using DCS simulation software

Course Outcomes
Upon completion of the course students will be able to
1. gain confidence in development of conventional/ wireless IoT based transmitter suited for real time processes
2. get exposure in design of different controller suitable for real time processes.
3. adequate programming skills using PLC, DCS and SCADA
4. gain knowledge on Ladder Logic programming.
Course Code : IC 602
Course Title : Industrial and Data Communications
Number of Credits : 3
Course Type : Core

Course Learning Objectives
1. To expose the students to Communication systems emerged in the field of industrial automation.
2. To learn the protocols used for data communication.
3. To test, build, wire and troubleshoot the different types of industrial data communication circuits used for instrumentation.
4. To expose the students to more advanced, precise and complex instrumentations which are being employed in the automation industry.

Course Content

Fieldbus: Use of fieldbuses in industrial plants, functions, international standards, performance, use of Ethernet networks, fieldbus advantages and disadvantages, Fieldbus design, installation, economics and documentation.

Instrumentation network design and upgrade: Instrumentation design goals, cost optimal and accurate sensor networks, Global system architectures, advantages and limitations of open networks, HART network and Foundation fieldbus network.

PROFIBUS-PA: Basics, architecture, model, network design and system configuration. Designing PROFIBUS-PA and Foundation Fieldbus segments: general considerations, network design.

HART and MODBUS - Concept of Highway Addressable Remote Transducer (HART), HART and smart Instrumentation, HART protocol, HART Physical layer, HART Data link layer, HART benefits, Troubleshooting of HART, Overview of Modbus protocol, Modbus protocol structure.

Text Books
Reference Books


Course Outcomes

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

1. understand the concepts required for building industrial systems.
2. explain various methods and protocols used for data communication.
3. troubleshoot problems in hardware/software employed in data communication circuit.
4. install various types of network devices and other network hardware for field and ProfiBUS.
Course Code: IC 604
Course Title: Electric Drives and Control
Number of Credits: 3
Course Type: Core

Course Objectives:
1. To introduce basic concepts of load and drive interaction.
2. To introduce to the students on the concept of employing power convertors for the design of electric drives.
3. To impart knowledge on the analysis of electric drive system dynamics.
4. To impart knowledge on the design and development of control methods for electric drive systems.

Course Content:


Hybrid, Variable Reluctance, and PM stepper motors-performance characteristics and time response-full and half step motor drives, micro-stepping- Switched reluctance motor drive, Brushless DC motor drive- PMSM drives, BLDC drive, drive controller design. Harmonics – input harmonics study, impact on connected grid, design of input filters; Output harmonics and impact on connected rotating machines (design considerations of driven machines)
Text Books:


Reference Books:


Course Outcomes:

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

1. design suitable power electronic circuit for an electric drive system and analyse its steady state stability.
2. select appropriate control method for the electric drives.
3. select a suitable electric drive for a particular industrial application.
4. design and implement a prototype drive system.
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<tr>
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<tr>
<td>Course Title</td>
<td>Robotics in Industrial Automation</td>
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**Course Learning Objectives**

1. To introduce the basic concepts, parts of robots and types of robots
2. To educate on various path planning techniques
3. To discuss about the various applications of robots
4. To familiarize about material handling in a system.

**Course Content**


Trajectory planning: Mathematical representation of Robots - Position and orientation – Homogeneous transformation-Various joints- Representation using the Denavit Hattenberg parameters - Degrees of freedom-Direct kinematics-Inverse kinematics- Linear and angular velocities-Manipulator Jacobian-Prismatic and rotary joints–Inverse -Wrist and arm singularity - Static analysis - Force and moment Balance- Trajectory planning, Pick and place operations, Continuous path motion, Interpolated motion, Straight line motion

Material handling: concepts of material handling, principles and considerations in material handling systems design, conventional material handling systems - industrial trucks, rail guided vehicles, conveyor systems, advanced material handling systems, automated guided vehicle systems, automated storage and retrieval systems(ASRS), Work-in-process Storage, Interfacing Handling and Storage with Manufacturing

Automated Inspection and Testing: Automated Inspection Principles and Methods, Sensor Technologies for Automated Inspection, Coordinate Measuring Machines, Other Contact Inspection Methods, Machine Vision, Other optical Inspection Methods. Robotic vision systems, image representation, object recognition and categorization, depth measurement, image data compression, visual inspection

Other applications: Application of Robots in welding, Spray painting, assembly operation, cleaning, robot for underwater applications. Gripper force analysis and gripper design for typical applications, design of multiple degrees of freedom, active and passive grippers - Factors influencing the choice of a robot, robot performance testing- Impact of robot on industry and society.
Text Books

Reference Books

Course Outcomes
On completion of this course, the students will be able to
1. explain the basic concepts of working of robot
2. apply their knowledge in handling the materials.
3. analyze instrumentation systems for inspection and testing
4. use robots in different applications
Course Code  :  IC 608
Course Title   :  AI and Robotics Laboratory
Number of Credits  :  2
Course Type  :  Laboratory

Course Learning Objectives
1. Impart knowledge on Robot programming and Robot operation control
2. Expose students to SCADA and various data communication protocols
3. To learn the ML and DL models
4. To implement the DL models for real time data.

List of Experiments
1. Operator control of Robot and jog the Robot
2. Robot Programming: “In-air” program (Point to Point motion)
4. Actuation of Pneumatic circuit for Rotary Pusher Module and interface with Programmable Logic Control
5. Actuation of Single Acting Cylinder using a two-way Pressure Valve using Flow Control Valve
6. Trouble Shooting the Sensor and Actuator using MAPS-6S Multistation
7. Simulation of movements in HMI and SCADA (using Analog data)
8. Signal processing (A/D and D/A) using SCALEX and NORMX Blocks.
9. Execute an Instruction from the cloud to stop the machine operation.
12. Configure and Visualize the Thing data using Modbus adapter.
13. Algorithm for Data pre-processing
14. Development of regression algorithms for the given data
15. Implementation of classification algorithms
16. Development of Deep network models
17. Application and case studies related to manufacturing industries
18. Application and case studies related to process industries

Course Outcomes
Upon completion of the course, students will be able to
1. understand the operation of robot, select a robot program and execute, stop and reset it in the required operating modes.
2. understand the process of conversion of digital data to analog and analog data to digital data for automation and gain adequate programming skills using PLC, DCS and SCADA.
3. understand the AI concepts.
4. implement the ML and DL concepts.
**Course Code** : IC 611  
**Course Title** : Artificial Intelligence in Industrial Automation  
**Number of Credits** : 3  
**Course Type** : Elective

**Course Learning Objective**

1. To identify potential areas for automation and justify need for automation  
2. Study the concepts of Artificial Intelligence.  
3. Learn the methods of solving problems using Artificial Intelligence.  
4. Apply the concepts of AI to attain industrial automation

**Course Content**


Production Economics - Methods of Evaluating Investment Alternatives, Costs in Manufacturing, Break Even Analysis, Unit cost of production, Cost of Manufacturing Lead time and Work-in-process.


Industrial AI applications and Case studies - Applications of Industrial AI in Monitoring, optimization and control.AI applications in Industry Automation using -natural language processing-computer vision-speech recognition-computer vision.
Text Books

Reference Books

Course Outcomes
On completion of this course, the students will be able to
1. understand basic AI algorithms.
2. identify appropriate AI methods to solve a given problem.
3. acquire knowledge about AI/ML/DL techniques in Industrial automation.
4. understand the levels of automation
Course Learning Objectives

1. To introduce the knowledge of internet along with the changing trends in the cyber technologies.
2. Understand the various security threats and vulnerabilities of the cyber world keeping in line with the industrial trends.
3. Understand how web technology works, how web server capability is used in industry, and the security problems engendered by such use.
4. Locate web technologies where they can be used securely for industrial automation.

Course Content


Information System Security Technology- Types and classes of attack, Policies, Standards, Guidelines and procedures, Malicious code and attacks, Firewalls, Cryptography, Attacks against cryptosystems.

Industrial Automation Culture versus Information Technology(IT) Paradigms- Considerations in adapting IT security methods to industrial automation, Threats, IT and industrial automation.


Industrial Automation Trends, Approaches, and Issues- Automation trends, Formal methods used to quantify and standardize, Important concepts and applications -Information security continuous monitoring(ISCM) strategy, The Smart Grid Maturity Model (SGMM), Future smart grid issues and automation security issues.

Text Books

Reference Books

Course Outcomes
On completion of this course, the students will be able to
1. get knowledge of security mechanisms, standards and state-of-the-art capabilities.
2. design new systems and infrastructure level security solutions.
3. develop and maintain new tools and technologies to enhance the security of applications in industrial automation.
4. identify and solve different cyber security threats.
Course Code : IC 615
Course Title : Embedded Systems
Number of Credits : 3
Course Type : Elective

Course Learning Objectives
1. To provide knowledge on building blocks of embedded system, input/output interfacing & Bus communication with processors.
2. To teach automation using scheduling algorithms and real time operating system.
3. To discuss on different phases & modeling of a new embedded product.
4. To involve discussions/practice/exercise onto revising & familiarizing the concepts

Course Content


Introduction to basic concepts of RTOS- Need, Task, process & threads, interrupt routines in RTOS, Multiprocessing and Multitasking, Preemptive and non-preemptive scheduling, Task communication- context switching, interrupt latency and deadline shared memory, message passing-, Inter process Communication – synchronization between processes-semaphores, Mailbox, pipes, priority inversion, priority inheritance, comparison of Real time Operating systems: VxWorks, µC/OS-II, RT Linux.


Application development: Objective, Need, different Phases & Modelling of the EDLC. choice of Target Architectures for Embedded Application Development-for Control Dominated-Data Dominated Systems-Case studies on Digital Camera, Adaptive Cruise control in a Car, Mobile Phone, automated robonoids, interface to sensors, GPS, GSM, Actuators.
Text Books

Reference Books

Course Outcomes
On completion of this course, the students will be able to
1. understand the functionalities of processor internal blocks, with their requirement.
2. understand the role and features of RT operating system, that makes multitask execution possible by processors.
3. understand multiple CPU based on either hardcore or soft core helps data overhead management with processing- speed reduction for µC execution.
4. to design embedded systems to perform dedicated function.
Course Code : IC 617
Course Title : Intelligent Transportation Systems
Number of Credits : 3
Course Type : Elective

Course Learning Objectives
1. This course covers the techniques used to improve the safety, efficiency and control of surface transportation systems.
2. Emphasis is placed on technological and operational issues of these systems and using them for incident detection and for intelligent traffic management.
3. This course provides the current and future Intelligent Transportation Systems (ITS) workforce with flexible, accessible ITS learning through training and educational resources.
4. This course will assist graduate students, educators and transportation professionals in developing their knowledge, skills and abilities to build technical proficiency for ITS.

Course Content
The Road to ITS – History of traffic congestion, Traditional approach to addressing demand vs. capacity, Development of a modern ITS approach, Costs and benefits, Making the case for ITS.

Systems Engineering and ITS Architecture – Defining systems engineering and its application to ITS, Benefits of developing ITS architecture, ITS service categories, Regional ITS architecture, Integrating ITS planning with the transportation planning process.

Elements of ITS Design – Interdisciplinary engineering coordination with ITS, Powering ITS equipment, Detection technologies and data collection and distribution, Field device site design considerations, Communications infrastructure.

The Backbone of ITS – Communications network topologies and configuration, Bandwidth requirements, Attributes of hardwired and wireless networks, Fiber-optic networks, Computer IT and ITS synergies. Connected Vehicles – Vehicle-to-vehicle and vehicle-to-infrastructure communications, Safety applications and connected vehicle safety pilot program, Communications security and legal liability, Interoperability and international initiatives.

System Operations and Maintenance – The ITS business, Constructability, Plans, specifications, and cost estimate deliverable package, Maintenance considerations during design, Operational challenges, Ongoing system maintenance, Budgeting support after initial deployment.

Text Books

Reference Books

**Course Outcomes**

Upon completing this course, the student will be able to

1. study the modern transport systems in a systematic and focused way.
2. understand the fundamentals of ITS, including ITS national/regional architectures, designing process and the state-of-the-practice technologies.
3. grasp technological and operational issues of ITS and using them for connected vehicles.
4. think mobility further through adaptable and modular solutions.
Course Code : IC 619
Course Title : Fluid Power Systems
Number of Credits : 3
Course Type : Elective

Course Learning Objectives
1. To understand the role of pneumatic and hydraulic systems in industrial automation.
2. To impart the principles of various pneumatic and hydraulic components.
3. To facilitate the design of hydraulic and pneumatic circuits.
4. To familiarize the operation, maintenance and troubleshooting of various fluid power system in industry.

Course Content


Pneumatic system and components: Introduction to Pneumatics – Compressors – Types – Air treatment – FRL Unit – Air control valves, Quick exhaust valves, pneumatic actuators. Fluid power circuit design, Speed control circuits, synchronizing circuit, Pneumo-hydraulic circuit, Sequential circuit design.


Fluid power system maintenance and troubleshooting: Fluidics – Introduction to fluidic devices. Fluid power circuits; failure and troubleshooting.

Text Books
Reference Books


Course Outcomes

On completion of this course, the students will be
1. understand the basics of fluid power system.
2. select the appropriate pneumatic and hydraulic system for a given application.
3. implement various fluid power circuits.
4. operate, maintain and troubleshoot industrial fluid power circuits.
Course Code  : IC 621  
Course Title  : Control Systems  
Number of Credits  : 3  
Course Type  : Elective

Course Learning Objectives
1. To equip the students with the fundamental concepts in control systems.
2. To familiarize with the linear control system models
3. To introduce about the system states and state space; System representation in states space form.
4. To impart knowledge in the control techniques for design of a larger scale of systems.

Course Content
Mathematical modelling of physical systems: Electrical systems - Electromechanical systems – Mechanical systems – Thermal systems.


Text Books
Reference Books


Course Outcomes

On completion of the course, the student will be able to

1. understand the concepts of closed loop control systems and its stability.
2. apply the control techniques to any electrical systems.
3. design the classical controllers such as P, PI, etc., for electrical systems.
4. understand the state space theory.
**Course Code** : IC 623  
**Course Title** : System Identification  
**Number of Credits** : 3  
**Course Type** : Elective

### Course Learning Objectives

1. To impart knowledge about the importance of system identification.  
2. To introduce empirical and data based modeling of large-scale systems.  
3. To train the students in parametric and nonparametric statistical models and estimation techniques.  
4. To expose the students to the algorithms and computational overheads involved in large-scale system modeling and control.

### Course Content

**System Identification** - Motivation and overview, Models of Discrete time and Linear Time Invariant (LTI) Systems, Convolution equation, Difference equations, Transfer functions, State space models, Discretization, Sampling and hold operations, Sampling theorem, Non-parametric models, impulse response, step response and frequency response models.

Disturbance models - Random processes, Representation of stationary processes, White-noise process, Auto-covariance function (ACF), Autoregressive moving average (ARMA) models.

Parametric model structures – Autoregressive with external input (ARX), Autoregressive Moving Average with exogenous input (ARMAX), Output Error (OE), Box Jenkins (BJ) and Prediction Error Minimization (PEM) - Structures and their applicability in real time.


Estimation of parametric models - Notions of prediction and simulation, Predictors for parametric models, Prediction-error methods, Instrumental variable method, Model structure selection and diagnostics - estimation of delay and order, Residual checks, Properties of parameter estimates, Model comparison and selection, Model validation.

### Text Books

Reference Books

Course Outcomes
On completion of this course, the students will be able to
1. understand system identification concept.
2. apply estimation techniques for parametric & nonparametric models.
3. estimate parameters using regression analysis.
4. design inputs for identification.
Course Learning Objectives
1. This course is designed to offer learners an introduction to Industry 4.0 and its applications.
2. Learners will gain deep insights into how smartness is being harnessed from data.
3. Learners will understand what needs to be done in order to overcome the challenges.
4. To familiarize in Industry 4.0 in healthcare services.

Course Content
Introduction to Industry 4.0- The Various Industrial Revolutions, Digitalisation and the Networked Economy, Drivers, Enablers, Compelling Forces and Challenges for Industry 4.0, Comparison of Industry 4.0 Factory and Today's Factory, Trends of Industrial Big Data and Predictive Analytics for Smart Business Transformation

Internet of Things (IoT) & Industrial Internet of Things (IIoT) & Internet of Services, Smart Manufacturing, Smart Devices and Products, Smart Logistics, Smart Cities, Predictive Analytics.


3D printing technologies, selection of material and equipment, develop a product using 3D printing in Industry 4.0 environment.
IIoT case studies, Industry 4.0 in healthcare services, Strategies for competing in an Industry 4.0 world

Text Books

Reference Books
Course Outcomes
On completion of this course, the students will be able to
1. understand the drivers and enablers of Industry 4.0.
2. appreciate the smartness in Smart Factories, Smart cities, smart products and smart services.
3. outline the various systems used in a manufacturing plant and their role in an Industry 4.0 world.
4. outlines a strategic framework to exploit new technologies to enable Healthcare 4.0.
Course Code : IC 612  
Course Title : Industrial Internet of Things  
Number of Credits : 3  
Course Type : Elective

Course Learning Objectives
1. To provide a good understanding of Internet of Things (IoT) and its envisioned deployment domains.
2. To provide an understanding of smart sensors/actuators with their internet connectivity for experimentation and designing systems.
3. To provide a overview about the various protocol standards deployed in the Internet of Things (IoT) domain and to make informed choices.
4. To impart knowledge in the design and development of IoT systems with enablement ensuring security and assimilated privacy.

Course Content
Introduction to Internet of Things - Overview of Internet of Things- the Edge, Cloud and the Application Development, Anatomy of the Thing, Industrial Internet of Things (IIoT - Industry 4.0), Quality Assurance, Predictive Maintenance, Real Time Diagnostics, Design and Development for IoT, Understanding System Design for IoT, Design Model for IoT.


System Design Perspective for IoT – Products vs Services, Value Propositions for IoT, Services in IoT, Design views of Good Products, Understanding Context, IoT Specific Challenges and Opportunities.


Text Books:

**Reference Books**

3. *The Internet of Things – Opportunities and Challenges*
4. Single Chip Controller and WiFi SOC
5. Wireless Connectivity Solutions
6. *Wireless Connectivity for the Internet of Things – One size does not fit all*

**Course Outcomes**

On the completion of this course, the students will be able to
1. understand the design architecture of IoT.
2. make choice of protocols and deployment in solutions.
3. comprehend the design perspective of IoT based products /services.
4. basic understanding of various Industrial IoT platforms
Course Code : IC 614
Course Title : Computer Vision and Image Processing
Number of Credits : 3
Course Type : Elective

Course Learning Objectives
1. To introduce the students to the emerging fields.
2. To familiarize with both established and emergent methods, algorithms and architectures.
3. To enable the students to apply computer vision and image processing techniques to solve various real-world problems, and develop skills for research in the field
4. To impart practical skills necessary to build computer vision applications

Course Content
Image Formation and Coordinate Transformations, Camera Matrix, Motion/Stereo Pin-hole model, Human eye, cognitive aspects of colour, 3D space; illumination; Sampling and Quantization, Coordinate transformations and camera parameters.


Segmentation - Concept of Figure vs. Ground, Watershed, Change Detection, Background Subtraction, Texture Segmentation, Gaussian Mixture Models - Applications in Color and Motion based Image Segmentation, Background Modeling and Shape Clustering.

Machine Learning techniques in Vision, Bayesian Classification, Maximum Likelihood Methods, Neural Networks; Non-parametric models; Manifold estimation, Support Vector Machines; Temporal sequence learning.

Introduction to Object Tracking - Exhaustive vs. Stochastic Search Shapes, Contours, and Appearance Models. Mean-shift tracking; Contour-based models

Object Modeling and Recognition Fundamental matrix and Epipolar geometry, Adaboost approaches: Face Detection and Recognition, Large Datasets; Attention models.

Applications: Surveillance, Object detection etc.

Text Books
Reference Books

Course Outcomes
On completion of this course, the students will be able to
1. understand the major concepts and techniques in computer vision and image processing
2. demonstrate computer vision and image processing knowledge by designing and implementing algorithms to solve practical problems
3. understand the type of algorithm required for a particular image processing task
4. implement common methods for robust image matching and alignment.
Course Code : IC 616
Course Title : Predictive Analytics
Number of Credits : 3
Course Type : Elective

Course Learning Objectives
1. Ability to develop and use various predictive models based on various regression and decision tree methods.
2. Understand how to formulate predictive analytics questions.
3. Learn how to select the appropriate method for predictive analysis.
4. Learn how to search, identify, gather and pre-process data for the analysis.

Course Content
Statistical Learning and Linear Regression- Supervised versus unsupervised learning, The trade-off between prediction accuracy and model interpretability, Regression versus classification problems, Simple linear regression, Multiple linear regression, Considerations in the regression model, Comparison of linear regression with K-Nearest Neighbors, Weighted Least Squares (WLS), Generalized Linear Models (GLM).

Overview of Classification and data processing- Logistic Regression - Logistic model, Estimating the regression coefficients, Making predictions, Multiple logistic regression, Linear Discriminant Analysis- Using Bayes’ theorem for classification, Quadratic Discriminant Analysis, Comparison of classification methods, Data preprocessing- Overview, Variable types, Data transformations, Count data models, Centering, Standardization, Rank transformations, Data reduction.

Linear Model Selection and Regularization- Subset selection, Dimension reduction methods- Principal components regression, Partial least squares, Considerations in high dimensions, regression in high dimensions. Tree-Based Methods- The basics of decision trees, Regression trees, Classification trees, Trees versus linear models, Advantages and disadvantages of trees, Bagging, Random forests, Boosting.


Unsupervised Learning- The challenge of unsupervised learning, Principal Components Analysis(PCA), Use of principal components, Clustering methods, K-means clustering, Hierarchical clustering

Machine Learning - Machine learning overview, Error measures, Cross-validation, Bias vs. variance tradeoff.
Text Books


Reference Books


Course Outcomes

On completion of this course, the students will be able to
1. develop a deep understanding of the predictive analytics life cycle.
2. work with various data types and how to pre-process the data for analysis.
3. learn the basic concepts behind machine learning.
4. learn the various methods to build predictive classification models using decision trees.
Course Learning Objectives
1. To overview the various design issues and challenges in the layered architecture of Wireless sensor networks.
2. Analyze various protocols used in wireless sensor networks.
3. To familiarize localization and tracking in networks
4. Learn about data handling in wireless sensor networks.

Course Content

Physical layer- Introduction, wireless channel and communication fundamentals – frequency allocation, modulation and demodulation, wave propagation effects and noise, channels models, spread spectrum communication, packet transmission and synchronization, quality of wireless channels and measures for improvement, physical layer and transceiver design consideration in wireless sensor networks.


Data Storage and Manipulation: Data centric and content based routing, storage and retrieval in network, compression technologies for WSN, Data aggregation technique. Case study-Detecting unauthorized activity using a sensor network, Target detection tracking, Habitat monitoring, Environmental disaster monitoring, Practical implementation issues, IEEE 802.15.4 low rate WPAN, Operating System Design Issues. Simulation tools.
Text Books

Reference Books

Course Outcomes
At the end of the course, student will be able to
1. analyze the challenges and constraints of wireless sensor network and its subsystems.
2. examine the physical layer specification, modulation and transceiver design considerations.
3. compare and analyze the types of routing protocols and data aggregation techniques.
4. identify the application areas and practical implementation issues.
Course Code : IC 620
Course Title : Augmented Reality
Number of Credits : 3
Course Type : Elective

Course Learning Objectives
1. To study the fundamentals of Augmented Reality (AR) modeling and programming
2. To understand the tools and platforms used in the AR and Virtual Reality (VR).
3. To learn the principles and multidisciplinary features of virtual reality
4. To develop virtual environments and simulators

Course Content


Designing and developing 3d user interfaces - Strategies for Designing and Developing Guidelines and Evaluation-3D User Interfaces for the Real World, AR Interfaces as 3D Data Browsers, 3D Augmented Reality Interfaces, Augmented Surfaces and Tangible Interfaces, Agents in AR, Transitional AR-VR Interfaces - The future of 3D User Interfaces, Questions of 3D UI Technology, 3D Interaction Techniques, 3D UI Design and Development, 3D UI

Text Books

Reference Books

Course Outcomes
On completion of this course, the students will be able to
1. understand AR models and programs
2. develop 3D interaction techniques
3. design 3D user interface
4. apply AR and VR tools for various industrial applications.
Course Code : IC 622
Course Title : Network Control Systems
Number of Credits : 3
Course Type : Elective

Course Learning Objectives
1. To introduce different models of network control system.
2. To introduce different estimation techniques for network control system.
3. To introduce different network control system techniques.
4. To introduce different applications suited for network control systems.

Course Content
Stochastic process – Introduction to random variables, Expectations, Moments, stationary and non-stationary process.

Network models – Stochastic model, communication network constraints, packet delay, packet loss, uncertain observation, Markov chain based model.

Estimation of networked control system – Observer for networked system, Kalman filter.
Control strategies – Output feedback control, Predictive control.

Introduction to graph theory, Simulation of network control system, Application of network control system.

Text Books

Reference Books
Course Outcomes
On completion of this course, the students will be able to

1. model the network control system with packet delay, loss and uncertain observation.
2. design control system in the presence of quantization, network delay or packet loss.
3. understand distributed estimation and control suited for network control system.
4. develop simple application suited for networked control systems.
Course Code : IC 624
Course Title : Modelling Simulation and Analysis of Manufacturing Systems
Number of Credits : 3
Course Type : Elective

Course Learning Objectives
1. Understand a model and document a problem.
2. Study different techniques to generate random variate.
3. Use the different simulation language to model and analyze problems found in industrial automation.
4. To design and analyze a simulation experiment.

Course Content
Principles of Modeling & Simulation - Basic Simulation Modeling, appropriate simulation, not appropriate simulation, Advantages and disadvantages and pit falls of simulation, Monte Carlo Simulation, Areas of applications, Discrete and Continuous Systems, Modeling of a system, Types of models, Discrete event simulation.

Modeling Approaches - Modeling complex systems, List processing in simulation, Simple simulation language, Single server queuing systems, Time shared computer model, Multiteller banking with jockeying, Job shop model.

Random Number Generation - Basic probability and statistics- random variables and their properties, Properties of random numbers, generation of pseudo random numbers, Techniques for generating random numbers, Various tests for random numbers-frequency test, and test for autocorrelation.

Random Variate Generation - Introduction, Different techniques to generate random variate: Inverse transform technique, Normal, Uniform, Weibull, Direct transformation technique for normal and log normal distribution, Convolution method and acceptance rejection techniques- Poisson distribution, Output Data Analysis for a single system - Types of simulation with respect to output analysis, transient and steady state behavior of a stochastic process.

Statistical Techniques - Comparison of two system design, Comparison of several system design – Bonferroni approaches to multiple comparisons for selecting best fit, for screening, Variance reduction techniques such as simple linear regression, Multiple linear regression.

Simulation Studies - Simulation of inventory problems, Discrete event simulation problems, Experimental design and optimization, 2k factorial designs, Simulation of manufacturing systems.
Text Books


Reference Books


Course Outcomes

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

1. analyze, model, and select appropriate input distributions and to explain simulation time advance mechanisms
2. understand types of simulation with respect to output analysis
3. apply appropriate simulation statistical output techniques
4. develop and apply appropriate random number and random variable generation techniques
Course Code: IC 626
Course Title: Rapid Prototyping
Number of Credits: 3
Course Type: Elective

Course Learning Objectives
1. To introduce about different classes of Rapid Prototyping (RP) systems.
2. To impart knowledge about applications of various RP processes.
3. To introduce about rapid tooling.
4. Understand about RP Technology selection.

Course Content
Introduction- Need for the compression in product development, History of Rapid Prototyping (RP) systems, Survey of applications, Growth of RP industry, Classification of RP systems.


Rapid Tooling - Indirect rapid tooling, Direct rapid tooling, soft tooling Vs hard tooling, Rapid Manufacturing Process Optimization- Factors influencing accuracy, data preparation errors, part building errors, errors in finishing, influence of part build orientation.


Text Books

Reference Books
Course Outcomes
On completion of this course, the students will be able to

1. understand the importance of time compression technologies
2. select of appropriate technology for particular application.
3. apply RP software packages
4. recognize various types of rapid tooling.