M. Tech

IN

INDUSTRIAL POWER AND AUTOMATION

CURRICULUM AND SYLLABI

(Applicable from 2023 admission onwards)

Department of Electrical Engineering

NATIONAL INSTITUTE OF TECHNOLOGY CALICUT

Kozhikode - 673601, KERALA, INDIA

The Program Educational Objectives (PEOs) of M. Tech in Industrial Power and Automation

PEO1	Apply enhanced knowledge and skills in the area of Industrial Power and Automation so as to excel in various sectors in modern power industry and/ or teaching and/or higher education and / or research.
PEO2	Engage in design of novel products and strategic solutions to real life problems in the areas of Industrial Power and Automation that are technically sound, economically feasible and socially acceptable.
PEO3	Exhibit professionalism, keep up ethics in profession and demonstrate communication skills, leadership qualities as well as willingness to work in groups.

Programme Outcomes (POs) of M. Tech in Industrial Power and Automation

PO1	Ability to independently carry out research /investigation and development work to solve practical problems.
PO2	Ability to write and present a substantial technical report/document.
PO3	Ability to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.
PO4	Ability to provide engineering solutions to the problems pertaining to Industrial Power and Automation by utilizing the acquired knowledge and to take up project management issues including financial and administrative challenges in the industries, having multidisciplinary nature.
PO5	Willingness and ability for the sustentation of professional ethics and social values while carrying out the responsibilities as an Industrial Power and Automation engineer/researcher in devising solutions to real life engineering problems in an independent manner, with a perspective to sustained lifelong learning process.

CURRICULUM

Total credits for completing the M. Tech programme in Industrial Power and Automation (IPA) is 75.

COURSE CATEGORIES AND CREDIT REQUIREMENTS:

The structure of M.Tech programme shall have the following Course Categories:

Sl. No.	Course Category	Minimum Credits
1.	Program Core (PC)	23
2.	Program Electives (PE)	15
3.	Institute Elective (IE)	2
4.	Projects	35

The effort to be put in by the student is indicated in the tables below as follows:
L: Lecture (One unit is of 50 minute duration)
T: Tutorial (One unit is of 50 minute duration)
P: Practical (One unit is of one hour duration)
O: Outside the class effort / self-study (One unit is of one hour duration)

PROGRAMME STRUCTURE

Semester-I

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Category
1.	EE6401E	Industrial Internet of Things	3	0	0	6	3	PC
2.	EE6402E	Industrial Energy Conservation and Management	3	0	0	6	3	PC
3.	EE6403E	Artificial Intelligence and Industrial Applications	3	0	0	6	3	PC
4.		Programme Elective – 1	3	0	0	6	3	PE
5.		Programme Elective – 2	3	0	0	6	3	PE
6.		Institute Elective	2	0	0	4	2	IE
7.	EE6491E	Colloquium	0	0	2	1	1	PC
8.	EE6492E	Industrial Power Lab 1	0	0	3	3	2	PC
		Total Credits	**17**	**0**	**5**	**38**	**20**	**--**

Semester-II

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Category
1.	EE6411E	Industrial Drives and Control	3	0	0	6	3	PC
2.	EE6412E	Industrial Instrumentation	3	0	0	6	3	PC
3.	EE6413E	Renewable Energy Integration and Control	3	0	0	6	3	PC
4.		Programme Elective – 3	3	0	0	6	3	PE
5.		Programme Elective – 4	3	0	0	6	3	PE
6.		Programme Elective – 5	3	0	0	6	3	PE
7.	EE6493E	Industrial Power Lab 2	0	0	3	3	2	PC
8.	EE6494E	Project Phase I	0	0	3	3	2	PC
		Total Credits	**18**	**0**	**6**	**42**	**22**	**--**

Semester-III

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Category
1.	EE7491E	Project Phase II *	0	0	6	3	3	PC
2.	EE7492E	Project Phase III	0	0	30	15	15	PC
		Total Credits	**0**	**0**	**36**	**18**	**18**	**--**

** To be completed during Summer*

Semester-IV

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Category
1.	EE7493E	Project Phase IV	0	0	30	15	15	PC
		Total Credits	**0**	**0**	**30**	15	**15**	**--**

List of Electives **

Sl. No.	Course Code	Course Title	L	T	P	O	Credit
1	MA6003E	Mathematical Methods for Power Engineering	3	0	0	6	3
2	EE6421E	Power Converters for Industrial Applications	3	0	0	6	3
3	EE6422E	Process Control and Automation	3	0	0	6	3
4	EE6423E	Computer Controlled Systems	3	0	0	6	3
5	EE6424E	Engineering Optimization and Algorithms	3	0	0	6	3
6	EE6425E	Industrial Communication	3	0	0	6	3
7	EE6426E	Robotic Systems and Applications	3	0	0	6	3
8	EE6427E	Sustainable Energy Systems and Design	3	0	0	6	3
9	EE6428E	Distribution Systems Management and Automation	3	0	0	6	3
10	EE6429E	SCADA Systems and Applications	3	0	0	6	3
11	EE6430E	Wireless and Sensor Networks	3	0	0	6	3
12	EE6431E	Network and Data Security	3	0	0	6	3

13	EE6432E	Advanced Algorithms and Data Structure Analysis	3	0	0	6	3
14	EE6433E	Industrial Load Modelling and Control	3	0	0	6	3
15	EE6434E	Industrial Operation and Control	3	0	0	6	3
16	EE6101E	Systems Theory	3	0	0	6	3
17	EE6102E	Nonlinear Systems and Control	3	0	0	6	3
18	EE6111E	Digital Control: Theory and Design	3	0	0	6	3
19	EE6112E	Optimal and Robust Control	3	0	0	6	3
20	EE6114E	Advanced Sensing Systems and Interfacing Circuits	3	0	0	6	3
21	EE6123E	Robotics and Computer Vision	3	0	0	6	3
22	EE6132E	Networked Control and Multiagent Systems	3	0	0	6	3
23	EE6141E	Automotive Sensors and Instrumentation	3	0	0	6	3
24	EE6212E	FACTS and HVDC	3	0	0	6	3
25	EE6221E	Power Quality Issues and Remedial Measures	3	0	0	6	3
26	EE6226E	Distributed Generation and Micro-Grids	3	0	0	6	3
27	EE6227E	Power System Automation	3	0	0	6	3
28	EE6230E	Development and Evaluation of Power Projects	3	0	0	6	3
29	EE6302E	Dynamics of Electrical Machines	3	0	0	6	3
30	EE6303E	Modern Digital Signal Processors	3	0	0	6	3
31	EE6322E	Static VAR Controllers and Harmonic Filtering	3	0	0	6	3
32	EE6327E	Computer Aided Design for Electromagnetic Systems	3	0	0	6	3
33	EE6603E	Energy Storage Systems for Electric Vehicle	3	0	0	6	3
34	EE6605E	EV Power train: Drives and Control	3	0	0	6	3
35	EE6601E	Sensors for EV system	3	0	0	6	3
36	EE6612E	EV Charging Infrastructure and Analysis	3	0	0	6	3
37	EE6614E	Electric Vehicle System Engineering and Policy	3	0	0	6	3
38	EC6105E	Electronic Product Design	3	0	0	6	3
Institute Electives							
1	ZZ6001E	Research Methodology	2	0	0	4	2
2	MS6174E	Technical Communication and Writing	2	1	0	3	2
3	IE6001E	Entrepreneurship Development	2	0	0	4	2

*** List of Electives offered in each semester will be announced by the Department. Any other PG level course of NITC approved by the Senate offered in the Institute can also be credited as elective with the prior approval from the Programme Coordinator. Students admitted with B. Tech /B. E other than in Electrical and Electronics Engineering are recommended to take EE6421E - Power Electronic Circuits as Programme Elective – 1.*

EE6401E INDUSTRIAL INTERNET OF THINGS

Pre-requisites: **NIL**

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Analyze the key elements of an IoT ecosystem and the drivers behind the adoption of IIoT systems in various industries.
CO2: Analyze the implementation systems for IIoT, including microcontrollers, wireless sensor nodes, communication protocols, and networking equipment.
CO3: Design and use sensors with IIoT systems and utilize technologies such as XBee, Arduino, and Raspberry Pi for data acquisition and automation.
CO4: Apply the significance of IoE in smart grids and its application in energy generation, transmission, distribution, and revenue models, as well as the role of IoT-enabled smart meters.

Introduction to Industrial IoT (IIoT) System
Elements of an IoT ecosystem. Technology drivers, Business drivers. Typical IoT applications. Trends and implications. Overview of IoT supported Hardware platforms. M2M - Machine to Machine, Web of Things (WoT). Internet and Web Layering Business aspects of the Internet of Things. Representational State Transfer (REST). Role of Internet of Things (IoT) and Industrial Internet of Things (IIoT) in Industry, Industry 4.0 revolutions. Major challenges of IoT

Implementation systems for IIoT
Microcontrollers and Embedded PC roles in IIoT, Wireless Sensor nodes with Bluetooth, WiFi, and LoRa Protocols and IoT Hub systems. Communication Protocols: IEEE 802.15.4, ZigBee, Z Wave, Bluetooth, NFC, RFID, Industry standards communication technology (LoRAWAN, OPC UA, MQTT). Overview and working principle of Wired and wireless Networking equipment - Router, Switches, Access Points, future networking communication, Real time case studies of IoT.

Sensors and Interfacing with IIoT
Sensors and Actuators for Industrial Processes, Sensor networks, Process automation and Data Acquisitions on IoT Platform, Network Fundamentals: Anatomy of a Sensor Network, Examples of Sensor Networks, Topology of a Sensor Network Communication Media. Types of Sensor Nodes, Storing Sensor Data. XBee Primer, Building an XBee-ZB Mesh Network, Arduino-Based Sensor Nodes, Hosting Sensors with Raspberry Pi. Enterprise data for IIoT, emerging descriptive data standards for IIoT, Cloud data base, Cloud computing, Configuring Arduino/Raspberry pi board for the IoT.

Internet on Energy (IoE)
Need for Internet on Energy (IoE) - Generalized approach of IoT into smart grid. Application of IoE in generation, transmission and distribution side, Home area network, Role of IoT in energy storage system and smart grid technology, Benefits and outcome of IoE in smart grid-IoT enabled smart meters and various electricity market price fixation – electricity revenue model based IoT system.

References:

1. M. Kranz, "*Building the Internet of Things: Implement New Business Models, Disrupt Competitors, Transform Your Industry*", Wiley, 2017.
2. S. Bhattacharjee and S. Kak, "*Practical Industrial Internet of Things Security: A Practitioner's Guide to Securing Connected Industries*", Apress, 2020.
3. P. Lea, "*Internet of Things for Architects: Architecting IoT solutions by implementing sensors, communication infrastructure, edge computing, analytics, and security*", Packt Publishing, 2018.
4. K. Schwab, "*The Fourth Industrial Revolution*", Crown Business, 2016.
5. B. Sinclair, "*IoT Inc.: How Your Company Can Use the Internet of Things to Win in the Outcome Economy*", International Society of Automation (ISA), 2017.
6. J. Biron and J. Follett, "*Foundational Elements of an IoT Solution*", O'Reilly Media, 2016.
7. Keysight Technologies, "*The Internet of Things: Enabling Technologies and Solutions for Design and Test, Application Note*", 2016.
8. O. Vermesan and P. Friess, "*Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems*", River Publishers.2016

EE6402E INDUSTRIAL ENERGY CONSERVATION AND MANAGEMENT

Pre-requisites: **NIL**

Total Lecture Sessions: 39

L	T	P	O	C
3	0	0	6	3

Course Outcomes:

CO1: Analyze the role of energy managers and use the skills and techniques required to implement energy management.
CO2: Design and quantify the energy intensive business activities in industries and organizations.
CO3: Apply the standard methodologies for energy audit in the workplace and energy audit Instruments.
CO4: Analyze energy efficient control scheme for electric motors and perform case study on load matching and selection of motors in industries.
CO5: Design the energy conservation methods in motors, pumps, fans, compressors, transformers, geysers, lighting schemes, air conditioning, refrigeration, cool storage.

Energy Efficiency and Auditing
Energy scenario - supply and demand, Energy intensive industries, Industrial use of energy; System approach and End use approach to efficient use of Electricity; Electricity tariff types; Energy auditing: Types and objectives-audit instruments-ECO assessment and Economic methods-specific energy analysis-Minimum energy paths-energy flow diagrams; consumption models-Case study.

Electric Motors and Controls
Electric motors- -Motor Efficiency and Load Analysis- Starting and Controls; Energy efficient Motors-Case study; Load Matching and selection of motors; Intelligent Motor controls- Variable speed drives- Pumps and Fans-Efficient Control strategies- Optimal selection and sizing; Case study.

Power Management and Lighting
Transformer Loading/Efficiency analysis, Feeder/cable loss evaluation, case study; Reactive Power Management-Capacitor Sizing-Degree of Compensation, case study; Peak Demand controls- Methodologies-Industrial load management schemes -case study.

Lighting- Energy efficient light sources-Energy conservation in Lighting Schemes- Electronic ballast-Power quality issues, case study.

Cooling, Heating, and Cogeneration
Electric loads of Air conditioning and Refrigeration-Energy conservation measures- Cool storage.; Solar Water Heaters-Power Consumption in Compressors, electric furnaces and Energy conservation measures; Electrolytic Process; Computer Controls- EMS; Cogeneration- -case study.

References:
1. Y P Abbi and Shashank Jain, "*Handbook on Energy Audit and Environment Management*", TERI, 2006
2. Albert Thumann, William J. Younger, Terry Niehus, "*Handbook of Energy Audits*", 2009
3. Giovanni Petrecca, "*Industrial Energy Management: Principles and Applications*", The Kluwer international series - 207,1999
4. Anthony J. Pansini, Kenneth D. Smalling, "*Guide to Electric Load Management*", Pennwell Pub; (1998)
5. Howard E. Jordan, "*Energy-Efficient Electric Motors and Their Applications*", Plenum Pub Corp; 2nd ed., 1994
6. Turner, Wayne C, "*Energy Management Handbook*", Lilburn, The Fairmont Press, 2001
7. Albert Thumann, "*Handbook of Energy Audits*", Fairmont Pr; 5th ed. (1998)
8. Albert Thumann, P.W, "*Plant Engineers and Managers Guide to Energy Conservation*", 7th ed., TWI Press Inc, Terre Haute, 2007
9. Donald R. W., "*Energy Efficiency Manual*", Energy Institute Press, 1986
10. Partab H., "*Art and Science of Utilisation of Electrical Energy*", Dhanpat Rai and Sons, New Delhi. 1975
11. Tripathy S.C, "*Electric Energy Utilization and Conservation*", Tata McGraw Hill, 1991
12. Barney L. Capehart, Wayne C. Turner, William J. Kennedy, "*Guide to Energy Management*", Fairmont Press, 6th ed., April 23, 2008.
13. Albert Thumann., William J. Younger, "*Handbook of Energy Audits*", Fairmont Press, 7th ed., 2016.

EE6403E ARTIFICIAL INTELLIGENCE AND INDUSTRIAL APPLICATIONS

Pre-requisites: **NIL**

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Apply the fundamentals of Artificial Intelligence.

CO2: Develop problem-solving skills using AI algorithms.

CO3: Develop proficiency in Machine Learning techniques.

CO4: Apply Natural Language Processing (NLP) and Computer Vision.

CO5: Analyze the application of AI for Industrial Applications.

Introduction to Artificial Intelligence

Introduction to Artificial Intelligence: Definition and scope of AI - History and evolution of AI - AI applications in various fields; Problem Solving and Search Algorithms: Problem representation - Uninformed search algorithms (breadth-first search, depth-first search) - Informed search algorithms (heuristic search, A*, etc.); Knowledge Representation and Reasoning: Logic-based knowledge representation - Predicate logic and first-order logic - Inference and reasoning techniques.

Machine Learning Techniques

Machine Learning Basics: Supervised learning, unsupervised learning, and reinforcement learning - Training and testing data - Evaluation metrics; Regression and Classification: Linear regression - Logistic regression - Decision trees and random forests - Support vector machines; Clustering and Dimensionality Reduction: K-means clustering - Hierarchical clustering - Principal Component Analysis (PCA); Neural Networks and Deep Learning: Basics of neural networks - Feedforward neural networks - Convolutional Neural Networks (CNN) - Recurrent Neural Networks (RNN).

Natural Language Processing and Computer Vision

Introduction to Natural Language Processing (NLP): Language processing and understanding - Text preprocessing and feature extraction - Word embeddings; NLP Techniques: Sentiment analysis - Named Entity Recognition (NER) - Text classification; Introduction to Computer Vision: Image representation and preprocessing - Feature extraction and image descriptors - Object detection and recognition; Deep Learning for Computer Vision - Convolutional Neural Networks (CNN) for image classification - Object detection algorithms (e.g., YOLO, Faster R-CNN) - Image segmentation – Simulation practices.

Industrial Applications of AI

AI in Robotics and Automation: Robot control and path planning - Reinforcement learning in robotics - Industrial automation and optimization - AI in Manufacturing and Supply Chain - Predictive maintenance - Quality control and defect detection - Supply chain optimization - Medical image analysis - Disease diagnosis and prognosis – Simulation practices.

References:

1. Stuart Russell and Peter Norvig, "*Artificial Intelligence: A Modern Approach*", 3rd ed., Pearson, 2021.
2. David L. Poole and Alan K. Mackworth, "*Artificial Intelligence: Foundations of Computational Agents*", Cambridge University Press, 2017.
3. Tom M. Mitchell, "*Machine Learning*", McGraw Hill, 1997.
4. Christopher M. Bishop, "*Pattern Recognition and Machine Learning*", Springer, 2006.
5. Ian Goodfellow, Yoshua Bengio, and Aaron Courville, "*Deep Learning*", MIT Press, 2016.
6. Daniel Jurafsky and James H. Martin, "*Speech and Language Processing*", 3rd ed., Pearson, 2019.
7. Steven Bird, Ewan Klein, and Edward Loper, "*Natural Language Processing with Python*", O'Reilly Media, 2009.
8. Richard Szeliski, "*Computer Vision: Algorithms and Applications*", Springer, 2010.

EE6491E COLLOQUIUM

Pre-requisites: **NIL**

L	T	P	O	C
0	0	2	1	1

Course Outcomes:

CO1: Analyze research papers in the field of Industrial Power and Automation to extract the main objectives and evaluate the effectiveness of the work through critical review.

CO2: Analyze and categorize emerging directions in cutting-edge technologies, demonstrating the ability to identify promising avenues for further exploration.

CO3: Develop a comprehensive report that provides a detailed description of the reviewed topic, incorporating relevant information and synthesizing key findings.

CO4: Develop effective communication skills by delivering an oral presentation that effectively conveys information, ideas, and insights related to the topic of study.

Each student will independently select a topic within the field of Industrial Power and Automation, preferably beyond the scope of the M.Tech syllabus, and deliver a seminar presentation lasting approximately thirty minutes. A committee comprising experts from diverse engineering fields will evaluate the quality of the presentations and assign grades to the students. Each student must submit two copies of their seminar write-up, preferably in electronic format. One copy will be returned to the student after receiving certification from the Chairman of the assessment committee, while the other copy will be archived in the departmental library.

EE6492E INDUSTRIAL POWER LAB 1

Pre-requisites: **NIL**

L	T	P	O	C
0	0	3	3	2

Total Practical Sessions: 39

Course Outcomes:

CO1: Discuss SCADA System and its application.
CO2: Develop PLC programming and develop PLC programs for process industry applications.
CO3: Design and develop Robot Studio software and its simulation capabilities.
CO4: Analyze IoT and its applications.
CO5: Prepare laboratory reports that clearly communicate experimental information in a logical and scientific manner.

List of Experiments

1. SCADA- Transmission Module RTU in Local and Remote Mode.
   a) Ferranti Effect
   b) VAR Compensation (Series and Shunt)
   c) Transmission Line Modelling
2. SCADA- Distribution Module RTU in Local and Remote Mode.
   a) Load Shedding
   b) Transformer Loading
   c) Study of Communication Link
3. Creation of HMI screen using Ignition SCADA software
4. PLC based experiments
   a) PLC program creation for process industry application using structure text and ladder diagram
   b) Distributed Control Systems application and logic operations (PLC based) with master and slave controllers
5. Simulation of Pick and Place Robot in robot studio software and implementation in ABB IRB 1200
6. IoT Experiments
   a) Web application to control multiple devices with Raspberry Pi.
   b) Vertical farming using IOT.
   c) IoT based battery status management system using ESP8266.

References:

1. Mini S. Thomas and John Douglas McDonald, "*Power System SCADA and Smart Grids*", CRC Press, 2015.
2. Stuart A. Boyer, "*SCADA: Supervisory Control and Data Acquisition*", ISA, 2013.
3. Ajay Kapoor and Reza Iravani, "*Power Distribution Automation*", CRC Press, 2016.
4. Fahd Hashiesh, "*SCADA for Electrical Power Systems*", CRC Press, 2019.
5. Jean-Yves Fiset, "*Human-Machine Interface Design for Process Control Applications*", ISA, 2016.
6. W. Bolton, "*Programmable Logic Controllers*", Newnes, 2015.
7. Khaled Kamel and Eman Kamel, "*Programmable Logic Controllers: Industrial Control*", CRC Press, 2017.
8. Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, and Giuseppe Oriolo, "*Robotics: Modelling, Planning and Control*", Springer, 2020.
9. Adeel Javed, "*IoT: Building Arduino-Based Projects*", Packt Publishing, 2016.
10. Arshdeep Bahga and Vijay Madisetti, "*Internet of Things: A Hands-On Approach*", VPT, 2014

EE6411E INDUSTRIAL DRIVES AND CONTROL

Pre-requisites: **NIL**

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Analyze the significance of industrial drives and their industrial applications.

CO2: Apply power electronic converters in industrial drives.

CO3: Analyze the performance of DC and AC Drives.

CO4: Design and development of control systems for industrial drives

Introduction to Industrial Drive

Basics of drive systems and their importance in industrial applications - Overview of industrial drive components: motors, drives, sensors, and actuators - Classification of drive systems; Electric Motors in Industrial Drives: Types of electric motors (DC motors, AC motors, brushless DC motor, permanent magnet synchronous motor), Motor characteristics and selection criteria, Motor control techniques; Power Electronic Converters in Industrial Drives: Basics of power electronics in drive systems, types of power converters.

DC Motor Drives

DC Drives: Working principles of DC drives - Control techniques for DC drives - Speed and torque control in DC drives, DC Drive System Modeling and Simulation: Mathematical modeling of drive components - Dynamic analysis of drive systems - Transient and steady-state analysis of drive systems - Transfer function and state-space representations - Simulation tools for drive systems.

AC Motor Drives

Principles and operation of AC drives, Control strategies for AC drives; Speed control techniques for AC drives: Variable Frequency Drives (VFDs), Field Oriented Control (FOC), AC Drive System Modeling and Simulation - Dynamic analysis of AC Drive systems - Transient and steady-state analysis of drive systems - state-space representations - Simulation tools for drive systems.

Control System Design and Implementation

Control System Basics: Open-loop and closed-loop control concepts; Control System Design: Controller selection and design criteria - PID controller design and tuning techniques - Advanced control strategies for industrial drives, Safety Considerations and Fault Diagnosis: Safety practices and standards in industrial drive systems - Fault detection, diagnosis, and troubleshooting techniques - Protection mechanisms for drive systems.

References:

1. Bose, B. K., "*Modern Power Electronics and AC Drives*," Pearson Education, 2002.
2. Dubey, G. K., "*Fundamentals of Electrical Drives*," CRC Press, 2018.
3. Pillai, P. C., "*A First Course on Electrical Drives*," Wiley, 2019.
4. Ramaiah, V., "*Industrial Drives: Electrical Theory and Application*," New Age International, 2015.
5. Veltman, A., "*Industrial Control Electronics*," Cengage Learning, 2018.
6. Austin Hughes and Bill Drury, "*Electric Motors and Drives: Fundamentals, Types, and Applications*", 4th ed., Newnes, 2020.
7. Seung-Ki Sul, "*Control of Electric Machine Drive Systems*", Wiley-IEEE Press, 2011.
8. Ned Mohan, "*Advanced Electric Drives: Analysis, Control, and Modeling Using MATLAB/Simulink*", Wiley, 2014.
9. James L. Kirtley Jr., "*Electric Drive Systems and Operation: An Industrial Guide*", Wiley-IEEE Press,2012

EE6412E INDUSTRIAL INSTRUMENTATION

Pre-requisites: **NIL**

Total Lecture Sessions: 39

L	T	P	O	C
3	0	0	6	3

Course Outcomes:

CO1: Analyze the static and dynamic response characteristics of a first-order and higher-order system.
CO2: Describe the working of active and passive sensors /Transducers for the measurement of different industrial variables.
CO3: Analyze the actuators and power supplies used for different measurement systems.
CO4: Design measuring instrument for different process industries.

Introduction to Industrial measurement systems

Industrial measurement systems – Functional elements of an instrument – Input-Output configuration of measuring instruments - Calibration - Generalized performance characteristics – static characteristics – Linearity, Accuracy, precision, Input Impedance, and Loading effect, dynamic characteristics – zero-order, first-order, second, third, and higher order system- Response to different forcing functions such as Impulse, step, Ramp and sinusoidal, etc. to zero, first, second third and higher order of systems. Identification of transducer models.

Sensors and transducers for different industrial variables

Pressure- Manometers, Diaphragm, Bellow, Capsule, Bourdon tube, Differential Pressure Transmitter (DPT), Measurement of vacuum: McLeod gauge, Cold cathode type and hot cathode type ionization gauges, Calibration, Temperature- RTD, Thermistor, Thermocouple, Radiation thermometers, Level - Float gauges, Displacer type, Bubbler system, Load cell, Capacitive sensors, Differential pressure methods, Ultrasonic level sensors, Flow- Orifice meter, Rotameter, Electromagnetic flow meter, Torque, Density- Oscillating Coriolis Densitometer, Displacement measurement- LVDT, RVDT, speed, pH and conductivity, Measurement of Viscosity, Humidity and Thermal conductivity.

Regulators & power supplies for industrial instruments

Industrial signal conditioning systems- Amplifiers – instrumentation amplifiers, Filters, voltage–current converters, voltage-frequency converters, analog multiplexers, and de-multiplexers for instruments in practical applications. Fundamentals of 4-20 mA current loops and 3-15psi pressure loops–review of general Industrial instruments.

Regulators and power supplies for industrial instrumentation – linear series voltage regulators – linear shunt voltage regulators – integrated circuit voltage regulators – switching regulators –single-ended isolated forward regulators- half and full bridge rectifiers. Servo drives – servo drive performance criteria – hybrid stepper motor – permanent magnet stepper motor – hybrid and permanent magnet motors.

Measurement in Process Industry

Case studies- Measurement in thermal power plant – Feed water flow, air flow, steam pressure and steam temperature, drum level measurement, radiation detector, smoke density measurement, Flue gas analyzer, Current measurement, Voltage measurement, 3 phase power measurement, Frequency measurement - CT, PT, Rogowski coils, LPCT, Power factor measurement - Petrochemical industry – Measurements in binary and fractional distillation columns.

References:

1. Doebelin E. O. and Manik D. N., "*Measurement Systems*", 6th ed. Tata McGraw-Hill Publishing Company Limited, 2017.
2. Johnson C. D., "*Process Control Instrumentation Technology*", 8th ed. Prentice Hall of India Private Limited, 2014.
3. Cooper W. D. and Helfrick A. D, "*Modern Electronic Instrumentation and Measurement Techniques*", Pearson Education, 2016.
4. Muhamad H Rashid, "*Power electronics handbook"*, Academic Press, 2007
5. Bela G. Liptak, "*Instrument Engineer's Handbook – Process Control"*, Chilton Company, 4th ed., 2006.
6. Andrew Williams, "*Applied instrumentation in the process industries*",3rd ed., Vol. 1 & 3, Gulf publishing company 2007.
7. Tattamangalam R. Padmanabhan "*Industrial Instrumentation Principles and Design*" Springer, May 2000.
8. K Krishnaswamy, *Industrial Instrumentation*, New Age International Publishers, New Delhi, 2003
9. Gregory K. McMillan, Douglas M. Considine, "*Process/Industrial Instruments and Controls Handbook"* ,5th ed., Mc Graw Hill 2009.

EE6413E RENEWABLE ENERGY INTEGRATION AND CONTROL

Pre-requisites: **NIL**

Total Lecture Sessions: 39

L	T	P	O	C
3	0	0	6	3

Course Outcomes:

CO1: Analyse of the operation and control of power systems with a specific emphasis on the challenges associated with integrating diverse renewable generation into the grid.

CO2: Design and analyze solar power generation systems utilizing photovoltaic (PV) panels, while also gaining exposure to various cell technologies

CO3: Design a deep understanding of wind energy-based renewable energy sources, and establish a solid foundation in power electronics stages employed for their integration.

CO4: Analyse the integration and control of renewable energy systems, while effectively analyzing stability issues that may arise in the process.

Introduction to Renewable Energy System

Various techniques of utilizing power from renewable energy sources, concept of nano/micro/mini grid. Need of integrating large renewable energy sources, issues related to integration of large renewable energy sources, ground mounted type, rooftop plants. Concept of VPP. Ancillary services in Indian Electricity Market (regulatory aspect), CERC and CEA orders (technical and safety standards).

Solar Photovoltaic System

Solar PV Cell and modules: Cell structure, front and back surface, I-V Characteristics, Efficiency & Quality of the Cell, series and parallel connections, maximum power point tracking, Applications, Different losses and mitigation, Anti reflective coating; properties and materials, the layers of PV modules, module mismatching, Shading and hot-spot formation, Environmental effect on PV module performance. need of power electronic equipment's in grid integration, DC-DC converter, inverter, chopper.

Wind Energy Conversion System

Working principle, classification – horizontal and vertical, stability due to variable speed and counter measures, Factors influencing wind, Variation of wind speed with height and time, Power speed characteristics, Power estimation in wind, MPPT operation, Wind energy conversion principles, Components of wind energy Conversion Systems (WECS), Classification of WECS, Stand Alone, Grid connected and hybrid WECS. Variable speed generators, Control systems, Power collection system.

Grid Integration and control

Introduction, principles of power injection: converting technologies, power flow; instantaneous active and reactive power control approach; integrating multiple renewable energy sources; DC link integration; AC link integration; HFAC link integration; islanding and interconnection. Based on synchronous/induction generator for peak demand reduction, grid connected PV system. stability due to variable speed and counter measures.

References:

1. C. S. Solanki, "*Solar Photovoltaics: Fundamentals, Technologies and Applications*", Prentice Hall of India, 2011.
2. S. P. Sukhatme "*Solar Energy-Principles of Thermal Collection & Storage*", TMH Publishing Co., New Delhi.
3. Majid Jamil, M. Rizwan, D.P.Kothari, "*Grid integration of solar photovoltaic systems*", CRC Press (Taylor & Francis group), 2017
4. llen J. Wood, Bruce F. Wollenberg, Gerald B. Sheblé, "*Power Generation, Operation, and Control*," AJohn Wiley & Sons, 3rd ed. New York, 2013
5. M.H.Rashid, "*Power Electronics: Circuits, Devices," and Applications*". Pearson Education India, 2013.
6. L.P.Singh, "*Advanced power system analysis and dynamics*", New age international publishers, 2017.

EE6493E INDUSTRIAL POWER LAB 2

Pre-requisites: **NIL**

L	T	P	O	C
0	0	3	3	2

Total Practical Sessions: 39

Course Outcomes:

CO1: Describe the fundamental principles and components of Power Converters.

CO2: Design and analyze the performance of a solar PV System.

CO3: Design the speed control performance of Motor Drives using a development kit.

CO4: Analyze the concepts of MIMO systems and their applications in control

CO5: Prepare laboratory reports that clearly communicate experimental information in a logical and scientific manner.

List of Experiments

1. Design of PCB schematic layouts for simple buck/boost converters using OrCad.
2. Design and Performance analysis of Buck converter (Simulation and Experimental setup).
3. Performance analysis of a Three-Phase Inverter (Simulation and Experimental setup).
4. Experiment on a Solar PV System.
   a) Study of P-V and I-V curves of a typical solar panel.
   b) Maximum Power Point tracking of a solar PV System (Simulation)
5. Speed control of Motor Drives using a development kit and real time testing.
   a) DC Motor
   b) PMSM
   c) BLDC
   d) Induction Motor
6. MIMO system for multiple level, flow and temperature controls.

References:

1. Montrose, Mark I., "*Printed Circuit Board Design Techniques for EMC Compliance: A Handbook for Designer*", Newnes, 2000.
2. Pressman, Abraham I., Billings, Keith, and Morey, Taylor. "*Switching Power Supply Design*", McGraw-Hill Education, 2009.
3. Mohan, Ned, Undeland, Tore M., and Robbins, William P., "*Power Electronics: Converters, Applications, and Design",* Wiley, 2018.
4. Scherz, Paul and Monk, Simon. "*Practical Electronics for Inventors",* McGraw-Hill Education, 2016.
5. Nise, Norman S. "*Control Systems Engineering"*. Wiley, 2015.
6. Bose, Bimal K. "*Modern Power Electronics and AC Drives"*. Pearson, 2001.

EE6494E PROJECT PHASE I

Pre-requisites: **NIL**

L	T	P	O	C
0	0	3	3	2

Course Outcomes:

CO1: Develop skill sets to take up projects through identifying problem formulation, methodology and outcome for giving solutions to small industrial technical problems.

CO2: Pursue a project under a topic of interest in the area of Electric Vehicle through literature search, design, numerical computations and hardware implementation.

CO3: Train on new technologies/tools to resolve industrial problems, which is cost-effective with a scope of product development.

CO4: Through presentation/ hardware demonstration, effectively share the knowledge learned/ solutions for the identified problem and write technical report about the work for publications in peer reviewed conferences/journals.

Guidelines:

Each student should identify a challenging topic in the area of Industrial applications of Power or Automation for the mini project and it has to be completed within one semester time span under the guide ship of any institute faculty. He/she can have additional guides from industries. Student has to study the topic and relevant literature to identify problem based on challenges, objectives, methodology, probable outcomes and work-time flow. Based on these, he shall submit a proposal. Student can utilize the laboratory setups, softwares available. In addition, they can take necessary data/information from industries/other technical institutions to improve the standard of the work. There will be review meetings to assess the progress of the work during the semester. After the completion of the work, students have to give oral presentations with hardware demonstration that would be evaluated by the committee. Once the committee approves the work, student can submit a detailed report in the prescribed format and get it duly signed by the guide and attested by the HOD.

EE7491E PROJECT PHASE II

Pre-requisites: **NIL**

L	T	P	O	C
0	0	6	3	3

Course Outcomes:

CO1: Develop comprehensive solution to issues identified in previous semester work and meet the requirements as stated in project proposal

CO2: Compile the results of the detailed analytical studies conducted and interpret the results for application to the instrumentation and control system.

CO3: Summarize the results and effectively communicate the research contributions and publish in reputed Journals /Conference or file a patent/copyright.

Guidelines:

Each student should identify a challenging topic in the area of Industrial applications of Power or Automation, which can be done as a project with in one or two semester(s) time span under the guide ship of any faculty from the Institute. He/she can have additional guides from industries also. Student has to study the topic and relevant literature to identify problem based on challenges, objectives, methodology, probable outcomes and work-time flow. Based on these, he shall submit a proposal. The problem shall be of sufficient size and challenging to come with innovative solutions. Student can utilize the laboratory setups, software's available. In addition, they can take necessary data/information from industries/other technical institutions to improve the standard of the work. There will be review meetings to assess the progress of the work during the semester. If he/she is doing the project based on the industrial problem, as a part of the internship in a reputed industry, there will be a guide from the industry also.

After the completion of the work, students have to give oral presentations with hardware demonstration that would be evaluated by the committee. Once the committee approves the work, student can submit a detailed report in the prescribed format and get it duly signed by the guide and attested by the HOD.

EE7492E PROJECT PHASE III

Pre-requisites: **NIL**

L	T	P	O	C
0	0	30	15	15

Course Outcomes:

CO1: Develop comprehensive solution to issues identified in previous semester work and meet the requirements as stated in project proposal

CO2: Compile the results of the detailed analytical studies conducted and interpret the results for application to the instrumentation and control system.

CO3: Summarize the results and effectively communicate the research contributions and publish in reputed Journals /Conference or file a patent/copyright.

Guidelines:

If the problem identified in second semester is sufficiently large and still more work is required to complete, same project can be extended to third semester as Project – Part III on approval by the evaluation committee.

Otherwise, the followings are guidelines:

Each student should identify a challenging topic in the area of Industrial applications of Power or Automation, which can be done as a project with in one semester time span under the guide ship of any faculty from the Institute. He/she can have additional guides from industries also. Student has to study the topic and relevant literature to identify problem based on challenges, objectives, methodology, probable outcomes and work-time flow. Based on these, he shall submit a proposal. The problem shall be of sufficient size and challenging to come with innovative solutions. Student can utilize the laboratory setups, softwares available. In addition, they can take necessary data/information from industries/other technical institutions to improve the standard of the work. There will be review meetings to assess the progress of the work during the semester. If he/she is doing the project based on the industrial problem, as a part of the internship in a reputed industry, there will be a guide from the industry also.

After the completion of the work, students have to give oral presentations with hardware demonstration that would be evaluated by the committee. Once the committee approves the work, student can submit a detailed report in the prescribed format and get it duly signed by the guide and attested by the HOD.

EE7493E PROJECT PHASE IV

Pre-requisites: **NIL**

L	T	P	O	C
0	0	30	15	15

Course Outcomes:

CO1: Develop comprehensive solution to issues identified in previous semester work and meet the requirements as stated in project proposal

CO2: Compile the results of the detailed analytical studies conducted and interpret the results for application to the instrumentation and control system.

CO3: Summarize the results and effectively communicate the research contributions and publish in reputed Journals /Conference or file a patent/copyright.

Guidelines:

If the problem identified in third semester is sufficiently large and still more work is required to complete, same project can be extended to fourth semester as Project – Part IV, on approval by the evaluation committee.

Otherwise, the followings are guidelines:

Each student should identify a challenging topic in the area of Industrial applications of Power or Automation, which can be done as a project with in one semester time span under the guide ship of any faculty from the Institute. He/she can have additional guides from industries also. Student has to study the topic and relevant literature to identify problem based on challenges, objectives, methodology, probable outcomes and work-time flow. Based on these, he shall submit a proposal. The problem shall be of sufficient size and challenging to come with innovative solutions. Student can utilize the laboratory setups, softwares available. In addition, they can take necessary data/information from industries/other technical institutions to improve the standard of the work. There will be review meetings to assess the progress of the work during the semester. If he/she is doing the project based on the industrial problem, as a part of the internship in a reputed industry, there will be a guide from the industry also.

After the completion of the work, students have to give oral presentations with hardware demonstration that would be evaluated by the committee. Once the committee approves the work, student can submit a detailed report in the prescribed format and get it duly signed by the guide and attested by the HOD.

MA6003E MATHEMATICAL METHODS FOR POWER ENGINEERING

Pre-requisites: **NIL**

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Solve systems of linear equations using the language of matrices.
CO2: Learn vectors spaces, eigenvalues and eigenvectors.
CO3: Solve unconstrained and constrained nonlinear programming problems.
CO4: Find approximate solutions to transcendental equations and system of equations using numerical methods.
CO5: Evaluate definite integrals and solve ODEs using numerical methods.

Linear Algebra

System of linear equations: Range space and Null space of a matrix, Rank of a matrix, Existence and uniqueness of solution of the system of linear equations, Dimension of the Solution Space associated with the system of linear equations.
Vector Spaces: Definition of Vector space, Sub spaces, linearly independence and dependence, linear Span, Basis, Dimension. Eigenvalues and Eigenvectors, Properties of eigenvalues and eigenvectors, Similarity matrices, Complex matrices.

Optimization Methods

Unconstrained one-dimensional optimization techniques, Necessary and sufficient conditions, Unrestricted search methods, Fibonacci and Golden section method. Unconstrained n dimensional optimization techniques, Descent methods, Steepest descent, conjugate gradient. Constrained optimization Techniques, Necessary and sufficient conditions, Equality and inequality constraints, Kuhn-Tucker conditions, Gradient projection method.

Numerical Methods

Solution of algebraic and transcendental equations: fixed point iteration method, Newton Raphson method. Solution of linear system of equations, Gauss elimination method, Pivoting, Gauss Jordan method, Iterative methods: Gauss Jacobi, Gauss Seidel and relaxation method, Newton's method for nonlinear system of equations. Numerical Integration: Trapezoidal and Simpson's rule, Composite integration methods, Gauss quadrature methods. Numerical Solution of Ordinary Differential Equations: Euler's method, Euler's modified method, Taylor's method, Runge-Kutta method, Multistep methods, Milne's and Adams' methods, Predictor-Corrector methods.

References:

1. G. Strang, Introduction to Linear Algebra, Wellesley MA: Cambridge Press, 2016.
2. D M Simmons, Nonlinear Programming for Operations Research, Prentice Hall, 1975.
3. G Mohan and Kusum Deep, Optimization Techniques, New age International Publishers,2009.
4. Jain M.K., Iyengar S.R.K., Jain R.K., Numerical methods for Scientific and Engineering
5. Computation, 8th edition, New Age International (P) Ltd, 2022.

EE6421E POWER CONVERTERS FOR INDUSTRIAL APPLICATIONS

Pre-requisites: **NIL**

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Describe the concepts of power electronics and its applications in industrial power and automation.

CO2: Analyze the characteristics, ratings, and selection criteria of power semiconductor devices for industrial applications.

CO3: Analyze different types of power converters used in industrial power electronic systems.

CO4: Apply the control techniques for power electronic systems in industrial applications.

Introduction to Power Electronics

Basics of power electronics: Introduction, history, and applications in industrial power and automation; Power semiconductor devices: Diodes, thyristors, power MOSFETs, IGBTs, and their characteristics, ratings, and selection criteria for industrial applications; Introduction to power electronic converters: AC-DC, DC-DC, DC-AC, and AC-AC converters, operation principles, and control strategies (block diagram approach).

Power Converters

DC-DC converters: Isolated and non-isolated topologies for industrial applications - buck, boost, buck-boost, and flyback converters; AC-DC converters: Rectifiers, power factor correction (PFC) techniques for industrial power supplies; DC-AC converters: Inverters, voltage source inverters (VSI), current source inverters (CSI); Multi-level converters: Diode-clamped, flying capacitor, cascaded H-bridge topologies; AC-AC converters: Cycle converter and matrix converter.

Control Techniques for Power Electronic Systems

Pulse width modulation (PWM) techniques: Sinusoidal PWM, space vector modulation (SVM); Control strategies for power electronic circuits in industrial power and automation applications - Voltage and current control strategies - PI control, hysteresis control, predictive control; Soft-switching techniques and their benefits in industrial power electronics - Resonant converters, zero voltage switching (ZVS), zero current switching (ZCS).

Industrial Applications of Power Electronics

Power electronic applications in motor drives for industrial automation; Power quality improvement techniques in industrial power systems- Active power filters, harmonics mitigation techniques; Power supplies for industrial applications: Switched-mode power supplies (SMPS), uninterruptible power supplies (UPS); Power electronics in renewable energy systems for industrial power generation - Solar inverters, wind turbine converters - Emerging trends and advancements in power electronics for industrial power and automation.

References:

1. Ned Mohan, Undeland, Tore M., Robbins, William P., "*Power Electronics: Converters, Applications, and Design*," Wiley, 2003.
2. Vithayathil Joseph, "*Power Electronics: Principles and Applications*," John Wiley & Sons, 2001.
3. Rashid, Muhammad H., "*Power Electronics: Circuits, Devices, and Applications*," Prentice Hall, 2004.
4. Williams, B. W., "*Power Electronics: Devices, Drivers, Applications, and Passive Components*," CRC Press, 2013.
5. Luo, Fang Lin, Ye, Hong, "*Power Electronics: Advanced Conversion Technologies*," CRC Press, 2010.
6. Bose, Bimal K., "*Power Electronics and Motor Drives: Advances and Trends*," Academic Press, 2006.
7. Rashid, Muhammad H., "*Power Electronics Handbook: Devices, Circuits, and Applications*," Academic Press, 2018.
8. Abu-Rub, Haitham, Malinowski, Mariusz, Al-Haddad, Kamal, "*Power Electronics for Renewable Energy Systems, Transportation and Industrial Applications*," Wiley, 2014.
9. Hussein, Khaled F., Ahmed, Mohamed E., Mohammed, Sabah, "*Power Electronics: Advanced Topics and Designs*," Springer, 2017

EE6422E PROCESS CONTROL AND AUTOMATION

Pre-requisites: **NIL**

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Analyse the dynamic characteristics of processes.

CO2: Analyze various control schemes used in industrial process.

CO3: Analyze interaction and control schemes used in multi variable process.

CO4: Design advanced processes control systems.

Process Modeling and Dynamic Characteristics

Process Modeling- Introduction to Process control -Hierarchies in process control systems-Theoretical models- General Modeling Principles, Degree of freedom analysis, Dynamic Models of Representative Processes, Transfer Function Models- Linearization of Nonlinear Models, State space models-Development of empirical models from process data-chemical reactor modeling. Dynamic Behavior Characteristics of First-Order and Second-Order Processes, Processes with Time Delays, Analysis using software.

Process Control Scheme

Feedback & Feedforward Control- Feedback controllers-PID design, tuning, troubleshooting-Cascade control- Selective control loops-Ratio control- Time-Delay Compensation-Inferential Control, Control system design based on Frequency response Analysis-Direct digital design- Feedforward and ratio control-State feedback control- LQR problem- Pole placement -Simulation using software- Control system instrumentation-Sensors, Transmitters, and Transducers-Control valves- Codes and standards- Preparation of P& I Diagrams.

Multi-variable Process Control Scheme

Advanced process control-Multi-loop and multivariable control-Process Interactions-Pairing of Controlled and Manipulated Variables, Singular value analysis-tuning of multi loop PID control systems-decoupling control-strategies for reducing control loop interactions-Real-time optimization-Simulation using software.

Introduction to Advanced Process control

Model predictive control - Batch Process control - Plant-wide control & monitoring - Plant wide control design- Instrumentation for process monitoring-Statistical process control-Introduction to Fuzzy Logic in Process Control - Introduction to OPC - Introduction to environmental issues and sustainable development relating to process industries.

References:

1. D.E. Seborg, T.E. Edgar, D.A. Mellichamp. "*Process Dynamics and Control*", Wiley India Pvt. Ltd., 4th ed., 2017.
2. Johnson D Curtis, "*Instrumentation Technology*", 7th ed., Prentice Hall India, 2002.
3. Bob Connel, "*Process Instrumentation Applications Manual*", McGrawHill, 1996.
4. Edgar, T.F. & D.M. Himmelblau, "*Optimization of Chemical Processes*", McGrawHill Book Co, 1988.
5. Macari Emir Joe and Michael F Saunders, "*Environmental Quality Innovative Technologies and Sustainable Development*", American Society of Civil Engineers, 1997.
6. Nisenfeld , A.E ,(Ed), "*Batch Control: practical guides for measurement and control*", Instrument Society of America, 1996.
7. Sherman, R.E. (Ed), "*Analytical instrumentation*", Instrument Society of America, 1996.
8. Shinskey, F.G., "*Process Control Systems: Applications, Design and Tuning*", 4th ed., McGrawHill Book Co, 1996.
9. B. Wayne Bequette, "*Process control: modeling, design, and simulation*", Prentice Hall PTR, 2003
10. K. Krishnaswamy, "*Process Control*", New Age International, 2nd ed. 2009.

EE6423E COMPUTER CONTROLLED SYSTEMS

Pre-requisites: **NIL**

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Analyze the multivariable system using Relative Gain Array RGA.

CO2: Describe the batch process control.

CO3: Analyze various control schemes used in industrial systems.

CO4: Design advanced control for large-scale control systems.

Multivariable Control

Introduction to batch process control. Batch distillation column, Batch mixing Tank, Batch reactor. Basic expressions for MIMO systems- Singular value analysis - Process Interaction, Pairing of Input and Outputs, Relative Gain Array (RGA) - Properties and Application of RGA, Multi-loop and Multivariable control, strategies for reducing control loop interactions, Design of Decoupler.

Industrial control schemes

Cascade control, Ratio control, feed-forward control. Over-ride, split range, and selective control. Introduction to Dynamic Matrix Control. Case Studies: Distillation column – control in Binary and fractional distillation column, pH control, and chemical reactor control, boiler drum level control - Single, two, and three-element control.

Programmable Logic Controllers

Organization of Programmable logic controllers- Hardware details- I/O- Power supply- CPU- Standards Programming aspects- Ladder Programming-Basic instructions, Ladder diagram symbols, Timer and Counter instruction- Arithmetic and logical instruction – MCR, PID controller, and other essential instruction sets - Case studies and examples for each instruction set Sequential function charts- Man-machine interface- Detailed study of one model- Case studies.

Large Scale Control System

Introduction- SCADA Architecture- Different Communication Protocols- Common System Components-Supervision and Control- HMI, RTU, and Supervisory Stations- Trends in SCADA- Security Issues.

DCS: Introduction to distributed control systems- DCS Architecture- Local Control (LCU) architecture- LCU languages- LCU - Process interfacing issues- communication facilities- configuration of DCS, displays, redundancy concept - case studies in DCS.

References:

1. D.E. Seborg, T.E. Edgar, D.A. Mellichamp. "*Process Dynamics and Control"*, Wiley India Pvt. Ltd., 4th ed., 2017.
2. Sigurd Skogestad, Ian Postlethwaite, "*Multivariable Feedback Control: Analysis and Design*", John Wilry ans Sons, 2005.
3. Bequette, "*Process Control: Modeling, Design, and Simulation*", Prentice Hall of India, 2004.
4. George Stephanopoulos, "*Chemical Process Control – An Introduction to Theory and Practice*", Prentice Hall of India, 2005.
5. F. G. Shinskey, "*Process control systems: application, Design and Tuning"*, McGraw Hill International Edition, Singapore, 1988.
6. R. C. Dorf and R. H. Bishop, "*Modern Control Systems",* Addison Wesley Longman Inc., 1999.
7. Stuart A. Boyer, "*SCADA-Supervisory Control and Data Acquisition"*, Instrument Society of America Publications, USA, 1999
8. Gordon Clarke, Deon Reynders, "*Practical Modern SCADA Protocols: DNP3, 60870.5 and Related Systems"*, Newnes Publications, Oxford, UK,2004

EE6424E ENGINEERING OPTIMIZATION AND ALGORITHMS

Pre-requisites: **NIL**

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Apply mathematical and numerical techniques of optimization theory to solve complex engineering problems.

CO2: Design real-world problems as mathematical optimization models and select appropriate algorithms for their solution.

CO3: Analyze modern optimization algorithms to solve large-scale optimization problems.

CO4: Describe the concepts of metaheuristic algorithms and apply them to solve complex engineering optimization problems.

CO5: Design the performance and efficiency of optimization algorithms and apply optimization techniques in multi-objective optimization problems.

Optimization Concepts and Applications

Introduction to optimization - Engineering applications of optimization - Classification of optimization problems - Types and size of optimization problems - Mathematical Preliminaries for Optimization: Convexity and concavity; Differentiation and integration techniques; Linear Programming: Standard form and geometric interpretation, Simplex method and variants, Duality and sensitivity analysis, Engineering Applications of Linear Programming.

Unconstrained Optimization Techniques

Gradient-Based Optimization Methods: Line search methods, Newton's method and variants - Convergence analysis and stopping criteria; Quasi-Newton Methods: BFGS and L-BFGS algorithms, Limited-memory methods - Stochastic Optimization: Stochastic gradient descent, Online learning and optimization; Engineering Applications of Unconstrained Optimization.

Constrained Optimization Techniques

Equality and Inequality Constrained Optimization - Karush-Kuhn-Tucker (KKT) conditions - Sequential quadratic programming (SQP) - Interior-point methods - Multi-Objective Optimization: Pareto optimality and Pareto front, Weighted sum and ε-constraint methods; Evolutionary multi-objective optimization algorithms, Engineering Applications of Constrained Optimization

Metaheuristic Algorithms and Large-Scale Optimization

Introduction to Metaheuristic Algorithms: Genetic algorithms - Particle swarm optimization - Simulated annealing - Ant colony optimization - Differential evolution - Evolutionary Strategies and Genetic Programming; Large-Scale Optimization Techniques: Decomposition methods - Surrogate-based optimization - Parallel and distributed optimization; Engineering Applications of Metaheuristic Algorithms and Large-Scale Optimization.

References:

1. David G. Luenberger, "*Linear and Nonlinear Programming*," 4^{th} ed., Springer, 2015.
2. Wayne L. Winston, "*Operations Research: Applications and Algorithms*," 4^{th} ed., Cengage Learning, 2013.
3. Xin-She Yang, "*Engineering Optimization: An Introduction with Metaheuristic Applications*," Wiley, 2010.
4. Thomas Weise, Raymond Chiong, Zbigniew Michalewicz, and Shengxiang Yang, "*Nature-Inspired Algorithms for Optimisation*," Springer, 2017.
5. Jürgen Branke, Kalyanmoy Deb, Kaisa Miettinen, and Roman Slowiński, "*Multiobjective Optimization: Interactive and Evolutionary Approaches*," Springer, 2008.
6. Carlos A. Coello Coello, Gary B. Lamont, and David A. Van Veldhuizen, "*Evolutionary Algorithms for Solving Multi-Objective Problems*," Springer, 2007.

EE6425E INDUSTRIAL COMMUNICATION

Pre-requisites: **NIL**

Total Lecture Sessions: 39

L	T	P	O	C
3	0	0	6	3

Course Outcomes:
CO1: Develop a comprehensive understanding of the industrial data communication systems
CO2: Describe inter-networking and serial communications.
CO3: Explain common principles, various standards and protocol stack in networking.
CO4: Design and apply industrial Ethernet and wireless communication.
CO5: Describe SCADA communication network and other open standard communication Protocols.

Fundamentals of Communication Networks
Fundamental of Industrial Data Communication Systems - Review of Data Acquisition, Automation Stem Architecture - Hierarchical Levels,Functional Layered Models - OSI reference model, System engineering approach, Input / Output Structures, Control Unit Structure, Protocols, Communication principles and modes: network topology, transmission media, noise, cable characteristic and selection; bridges, routers and gateways, Instrumentation and control devices.

Advanced Topics in Networking
Industrial Communication Standards and Protocols: (18 T) - Serial communication standards: Standards organizations, Serial - data communication interface standards, Balanced and unbalanced - transmission lines, Synchronous and asynchronous - communication, RS 232,422,485 standards. Industrial protocols: XON/OFF Signaling, Binary Synchronous Protocol (BSC),HDLC/SDLC protocol, CSMA/CD, CA protocol, OSI - implementation for Industrial communications, Industrial control - applications: ASCCII-based protocol – ANSI –X 3.28 -2.5 - IEC 61850 protocols.

Direct Link Networks
Direct link Networks: Framing; Error detection; Reliable transmission; Multiple access protocols; Concept of LAN-Ethernet LAN – Ethernet frame structure-Ethernet (IEEE 802.3); Token Rings (IEEE 802.5 & FDDI); Address Resolution Protocol- IEEE 802.11 LAN's- architecture and media access protocols, hubs, bridges, switches, PPP, ATM, wireless LAN, HART Communication Protocol, Architecture - physical, data link, application layer, communication, technique, normal and burst mode of communication, benefits of HART.

Open Industrial Fieldbus Systems
Open industrial Fieldbus and DeviceNet systems - Industrial Ethernet: 10Mbps, 100Mbps Ethernet, Gigabit Ethernet, Industrial Ethernet. Foundation fieldbus: Fieldbus requirement, features, advantages, fieldbus components, types, architecture–physical, data link, application layer, system and network management, wiring, segment functionality checking, function block application process. PROFIBUS: Architecture, OSI-model, PROFIBUS types – PA, DP & FMS and their comparison, Designing PROFIBUS, Network design, Advantages and Applications of PROFIBUS in industries.

References:

1. Karanjith S.Siyan, "*Inside TCP/IP*.", 3rd ed., Techmedia, 1998
2. Alberto,Leon,Garcia, Indra, and Wadjaja, "*Communication networks*", Tata Mc Graw Hill, 2000
3. James F Kurose.Keith W Ross, "*Computer networking A Top down Approach featured internet*", Pearson Education, 2003.
4. Keshav, "*An engineering approach to computer networking*", Addison-Wesley, 1999
5. Radia Perlmal, "*Interconnections*", 2nd ed., Addison Wesley, 2000
6. Douglas E comer, "*Inter networking with TCP/IP*", Vol 1, Prentice Hall India, 1999.
7. Andrew S. Tannebaum, "*Computer Networks*", 4th ed., Prentice Hall,2003
8. Stuart A. Boyer, "*SCADA-Supervisory Control and Data Acquisition*", Instrument Society of America Publications, USA,1999.
9. Gordon Clarke, Deon Reynders, *"Practical Modern SCADA Protocols: DNP3, 60870.5 and Related Systems"*, Newnes Publications, Oxford, UK, 2004
10. Afritech Panel, *"Industrial communication"*, Afritech, 2006
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12. Richard Zurawski, "*The industrial communication technology handbook*", CRC Press, 2005
13. Raimond Pigan, Mark Metter, "*Automating with PROFINET: Industrial Communication Based on Industrial Ethernet*", Publishing 2008

EE6426E ROBOTIC SYSTEMS AND APPLICATIONS

Pre-requisites: **NIL**

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Apply the mathematics of spatial descriptions and transformations.
CO2: Describe the robot system components that combines embedded hardware, software and mechanical systems.
CO3: Analyse manipulator kinematics and mechanics of robotic motion.
CO4: Apply the manipulator dynamics, transformation of acceleration, and robot controller architecture.
CO5: Apply artificial intelligence techniques in robotics.
CO6: Design various robotics applications and their associated components and control systems.

Foundations and Transformations
Mathematics of Spatial Descriptions and Transformations-Robot definition. Robot classification. Robotic system components- Notations- Position definitions- Coordinate frames - Different orientation descriptions - Free vectors- Translations, rotations and relative motion - Homogeneous transformations.

Robot Manipulator Kinematics and Mechanics
Manipulator Kinematics and Mechanics of Robot Motion-Link coordinate frames- Denavit-Hartenberg convention - Joint and end-effector Cartesian space-Forward kinematics transformations of positionInverse kinematics of position-Translational and rotational velocities -Velocity TransformationsManipulator Jacobian -Forward and inverse kinematics of velocity-Singularities of robot motion-Static Forces-Transformations of velocities and static forces -Joint and End Effector force/torque transformations Derivation for two link planar robot arm as example.

Dynamic Robotic Control and Planning
Manipulator Dynamics- Transformations of acceleration- Trajectory Planning- Control-Lagrangian; formulation- Model properties - Newton-Euler equations of motion- Derivation for two link planar robot arm as example- Joint space-based motion planning - Cartesian space-based path planning-Independent joint control- Feed-forward control-Inverse dynamics control-Robot controller architectures. Implementation problems

Sensing, Vision, and Programming
Robot Sensing and Vision Systems- Sensors-Force and torque sensors-low level vision-high level vision Robot Programming languages-Introduction to Intelligent Robots-Robots in manufacturing automation.

References:

1. Fu, K.S., R.C. Gonzalez, C.S.G. Lee, "*Robotics: Control, Sensing, Vision & Intelligence*", McGrawHill, 1987.
2. Craig, John J., "*Introduction to Robotics: Mechanics & Control*", 2nd ed., Pearson Education, 1989.
3. Gray J.O., D.G. Caldwell(Ed), "*Advanced Robotics & Intelligent machines*", The Institution of Electrical
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6. Groover Mikell P., M. Weiss, R.N. Nagel, N.G. Odrey, "*Industrial Robotics*", McGrawHill, 1986.
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8. Sciavicco, L., B. Siciliano, "*Modelling & Control of Robot Manipulators*", 2nd ed., Springer Verlag, 2000.
9. Robin R. Murphy, "*An introduction to AI Robotics*", MIT Press, 2008
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EE6427E SUSTAINABLE ENERGY SYSTEMS AND DESIGN

Pre-requisites: **NIL**

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Apply sustainable energy systems and their significance in addressing global energy challenges.
CO2: Design various renewable energy sources and their technologies.
CO3: Analyse energy efficiency and conservation practices in sustainable energy systems.
CO4: Design energy storage systems and their integration into the grid.
CO5: Describe the policy, economic, and regulatory aspects of sustainable energy.

Introduction to Sustainable Energy Systems
Introduction to Sustainable Energy - Global energy scenario and the need for renewable energy - Environmental, social, and economic aspects of sustainability - Renewable Energy Sources - Overview of different renewable energy sources (solar, wind, hydro, biomass, geothermal) - Technology, availability, and potential of each renewable energy source; Energy Efficiency and Conservation: Importance of energy efficiency and conservation in sustainable energy systems - Energy-efficient technologies and practices in buildings, industries, and transportation, Energy auditing and energy management techniques - Energy Policy and Planning - Energy policy frameworks and regulations promoting sustainable energy – Over view on Net zero emissions, Circular Economy, Carbon Footprint, Carbon Credits, etc.

Sustainable Energy Technologies
Solar Photovoltaic systems: principles, components, and design considerations; Solar thermal systems: applications, design, and performance analysis; Concentrated solar power (CSP) systems: technologies and operation; Wind turbine technology: types, components, and operation - Wind resource assessment and site selection - Grid integration and power quality issues in wind energy systems; Hydropower systems: types, components, and operation; Tidal, wave, and ocean thermal energy conversion (OTEC) systems; Environmental impacts and considerations in hydropower and ocean energy; Biomass resources: types, availability, and characteristics; Bioenergy conversion technologies: biofuels, biogas, and bioelectricity.

Energy Storage and Grid Integration
Battery technologies: types, characteristics, and applications - Thermal energy storage (TES) systems - Pumped hydro storage (PHS) and other grid-scale energy storage options - Power electronic converters for renewable energy systems - Grid codes and standards for renewable energy integration - Control and management strategies for grid-connected renewable energy systems - Microgrid concepts and components - Intelligent control and energy management in microgrids - Smart grid technologies and their role in sustainable energy systems - Design principles and methodologies for sustainable energy systems - Techno-economic analysis and optimization techniques - Case studies and real-world applications of energy system design.

Sustainable Energy Policy and Economics
Economics of renewable energy technologies - Financial models and incentives for sustainable energy projects - Life-cycle cost analysis and return on investment (ROI) calculations - National and international energy policies for sustainable energy - Feed-in tariffs, net metering, and other policy mechanisms - Carbon pricing and emission trading schemes - Challenges and barriers in transitioning to sustainable energy systems - Energy markets and future trends in renewable energy - Innovations and emerging technologies in sustainable energy.

References:
1. Henrik Lund, "*Renewable Energy Systems: A Smart Energy Systems Approach to the Choice and Modeling of 100% Renewable Solutions*," Academic Press, 2014.
2. Jefferson W. Tester, Elisabeth M. Drake, Michael J. Driscoll, Michael W. Golay, and William A. Peters, "*Sustainable Energy: Choosing Among Options*," The MIT Press, 2005.
3. Gilbert M. Masters, "*Renewable and Efficient Electric Power Systems*," Wiley, 2004.
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5. James F. Manwell, Jon G. McGowan, and Anthony L. Rogers, "*Wind Energy Explained: Theory, Design and Application*," Wiley, 2010.
6. John A. Duffie and William A. Beckman, "*Solar Engineering of Thermal Processes,*" Wiley, 2013.
7. Robert Huggins, "*Energy Storage*," Springer, 2018.
8. Jan Pettersen, "*Energy Policy Analysis: A Conceptual Framework*," Wiley, 2017

EE6428E DISTRIBUTION SYSTEMS MANAGEMENT AND AUTOMATION

Pre-requisites: **NIL**

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Apply the architecture, functions and implementation strategies of Distribution Automation Systems and Distribution Management Systems.

CO2: Apply different Intelligent Electronic Devices and Data Concentrators used for Distribution Automation Systems.

CO3: Analyze the usage of different communication systems, its protocols and architectures for implementation for control and automation of Distribution systems.

CO4: Apply automation to substation.

Distribution Automation and Management systems
Distribution Automation (DA) System: Introduction to Subsystems in a distribution control center, Necessity, System Control Hierarchy- Basic Architecture and implementation Strategies for DA- DMS framework: Integration with subsystems, Basic Distribution Management System (DMS) Functions-Real-time DMS applications. Advanced analytical DMS applications, DMS coordination, Customer automation functions.

Intelligent Electronic Devices and Data Concentrators
Intelligent Electronic Devices (IEDs), Evolution of IEDs, IED functional block diagram, The hardware and software architecture of IED, IED Communication subsystem, IED advanced functionalities, Typical IEDs, Data Concentrators and Merging Units.

Wireless and Wired Communication
Communication Systems for Control and Automation- Wireless and wired Communications- DA Communication Protocols, Architectures and user interface OSI seven-layer model Enhanced performance architecture (EPA) model-TCP/IP model-Modbus- IEC 60870-5-101/103/104 .Distributed network protocol 3 (DNP3), Inter-control center protocol (ICCP),Ethernet, IEC 61850,Protocols in the power system: Deployed and evolving.

Substation automation
Justification for Substation automation - Conventional substations. smart devices for substation automation-integrated digital substation-: Technical issues in Substation automation -Substation automation architectures-Comparison of New and existing substations-Substation automation application functions- SA practical implementation: Substation automation laboratory-Hardware design Software components. Case studies in substation automation.

References:

1. James Northcote – Green, Robert Wilson, "*Control and Automation of Electrical Power Distribution Systems"*, CRC Press, New York, 2007.
2. Mini S. Thomas and John D. McDonald, "*Power Systems SCADA and Smart Grid*" Taylor & Francis Group, LLC. 2015
3. Stauss C., "*Practical Electrical Network Automation and Communication Systems*", Elsevier Eastern Limited. 2003
4. McDonald J. D., "*Electric Power Substations Engineering*", CRC Press. Taylor and Francis 2003.
5. Brand K., Lohmann V. and Wimmer W., "*Substation Automation Handbook*", Utility Automation Consulting Lohman. 2003.
6. Dr M K Khedkar and Dr G M Dhole, "*A Textbook of Electric Power Distribution Automation*", University Science Press, 2011
7. D. Bassett, K. Clinard, J. Grainger, S. Purucker, and D. Ward, "*Tutorial Course: Distribution Automation*", IEEE Tutorial Publication 88EH0280-8-PWR, 1988.
8. James A. Momoh, "*Electric Power Distribution, Automation, Protection, and Control*", CRC Press, Taylor and Francis Group, 2007.

EE6429E SCADA SYSTEMS AND APPLICATIONS

Pre-requisites: **NIL**

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Analyze Supervisory Control Systems (SCADA) as well as architecture and system components.

CO2: Design various industrial communication technologies in SCADA.

CO3: Apply the important components such as PLC, SCADA, DCS, I/O modules and field devices of an industrial automation system.

CO4: Analyse PLC programs in different languages for industrial applications.

Introduction to SCADA & Components

Evolution of SCADA, Hardware, Software, Communication technologies, Monitoring and supervisory functions, SCADA Functional requirements and Components, SCADA Hierarchical concept, SCADA architecture, General features, SCADA applications in Utility Automation, Industries, Schemes- Remote Terminal Unit (RTU), Intelligent Electronic Devices (IED), Programmable Logic Controller (PLC), Communication Network, Master-slave, SCADA Server, SCADA/Human Machine Interface (HMI) Systems, Various SCADA architectures, single unified standard architecture.

SCADA Communication

SCADA Communication: various industrial communication technologies -wired and wireless methods and fiber optics, IEC 61850-based communication, Open standard communication protocols.

Remote Terminal Unit (RTU)- configuration, communication interface, control processor, Analog input/ output modules, Digital input/output module, Discrete control, Analog control, Pulse control, Serial control, Power supply module, Testing, and maintenance

Master Terminal units (MTU) – communication architecture, Features, and functions, Master station software, local area networks, Application, and data storage.

SCADA Applications

SCADA Applications: SCADA operating costs, Utility applications- Transmission and Distribution sector -operations, monitoring, analysis and improvement, scanning and communications, Operator Interface- alarming, system security, control change screens, status screens, graphics and trends, and reports.

Automatic control Industries - oil, gas, and water. Case studies, Implementation, Simulation Exercises.

Programmable Logic Controllers

Evaluation of PLC, PLC Architecture, Basic Structure. PLC Programming: Ladder Diagram – Basic instructions, Ladder diagram symbols, Timer and Counter instruction- Arithmetic and logical instruction – MCR, PID controller, and other essential instruction sets - Case studies and examples for each instruction set. PLC Communications and Networking, PLC Selection: I/O quantity and Type, Memory size and type, Programmer Units, Programming of PLC using simulation software – Real-time interface and control of process rig/switches using PLC, Interfacing PLC to SCADA.

References:

1. Stuart A. Boyer, "*SCADA-Supervisory Control and Data Acquisition*", Instrument Society of America Publications, USA,2004.
2. Gordon Clarke, Deon Reynders, "*Practical Modern SCADA Protocols: DNP3, 60870.5 and Related Systems*", Newnes Publications, Oxford, UK,2004.
3. William T. Shaw, "*Cybersecurity for SCADA systems*", PennWell Books, 2006.
4. F.D. Petruzella, "*Programmable Logic Controllers*", Tata Mc-Graw Hill, 3rd ed., 2010
5. David Bailey, Edwin Wright, *"Practical SCADA for industry"*, Newnes, 2003
6. Edward J.M. Colbert and Alexander Kott, "*Cyber-security of SCADA and other industrial control Systems*", Springer, 2016.
7. Dieter K. Hammer, Lonnie R. Welch, Dieter K. Hammer, "*Engineering of Distributed Control Systems*", Nova Science Publishers, USA, 1st ed., 2001

EE6430E WIRELESS AND SENSOR NETWORKS

Pre-requisites: **NIL**

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Apply the knowledge of wireless sensor networks (WSN) to various application areas.

CO2: Design and implement WSN.

CO3: Analyze the performance analysis of WSN and manage WSN

CO4: Design and solve problems creatively in the area of WSN.

Fundamentals of Sensor Networks and Network Architecture

Fundamentals of wireless communication technology - Introduction to Sensor Networks, unique constraints and challenges, Advantage of Sensor Networks, Applications of Sensor Networks, Mobile Adhoc NETworks (MANETs) and Wireless Sensor Networks, LANs, PANs, WANs, and MANs, Enabling technologies for Wireless Sensor Networks. Sensor Node Hardware and Network Architecture: Single-node architecture, Hardware components & design constraints, Operating systems and execution environments.

Foundations of Wireless Sensor Networks

Introduction to TinyOS and nesC - Network architecture, Optimization goals and figures of merit, Design principles for WSNs, Service interfaces of WSNs, Gateway concepts. Deployment and Configuration: Localization and positioning, Coverage and connectivity, Single-hop and multi-hop localization, self configuring localization systems, sensor management.

Networking and Routing Protocols

Network Protocols: Issues in designing MAC protocol for WSNs, Classification of MAC Protocols, S-MAC Protocol, B-MAC protocol, IEEE 802.15.4 standard and Zig Bee, Dissemination protocol for large sensor network. Routing protocols: Issues in designing routing protocols, Classification of routing protocols, Energy-efficient routing, Unicast, Broadcast and multicast, Geographic routing. Communication protocols: UART, SPI, Ethernet, HART,NFC, MODBUS, DNP3(Prerequisite Parameters to communicate using this protocols in any software (say, softwares like TriangleMathworks(Proprietary Software) for DNP3) , PROFIBUS

Data Storage and Applications

Data Storage and Manipulation: Data centric and content based routing, storage and retrieval in network, compression technologies for WSN, Data aggregation technique. Applications: Detecting unauthorized activity using a sensor network, WSN for Habitat Monitoring.

References:

1. Holger Kerl, Andreas Willig, "*Protocols and Architectures for Wireless Sensor Network"*, John Wiley and Sons, 2005 (ISBN: 978-0-470-09511-9).
2. Raghavendra, Cauligi S, Sivalingam, Krishna M., Zanti Taieb, "*Wireless Sensor Network"*, Springer 1st Ed. 2004 (ISBN: 978-4020-7883-5).
3. Feng Zhao, Leonidas Guibas, "*Wireless Sensor Network"*, Elsevier, 1st Ed. 2004 (ISBN: 13- 978-1- 55860-914-3)
4. Kazem, Sohraby, Daniel Minoli, Taieb Zanti, "*Wireless Sensor Network: Technology, Protocols and Application*", John Wiley and Sons 1st Ed., 2007 (ISBN: 978-0-471-74300-2).
5. B. Krishnamachari, "*Networking Wireless Sensors"*, Cambridge University Press.
6. N. P. Mahalik, "*Sensor Networks and Configuration: Fundamentals, Standards, Platforms, and Applications"*, Springer Verlag.

EE6431E NETWORK AND DATA SECURITY

Pre-requisites: **NIL**

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Discuss about information security governance, and related legal and regulatory issues.

CO2: Analyze external and internal security threats to an organization.

CO3: Apply information security awareness and understanding of its importance

CO4: Analyze the threats to an organization and select suitable solution strategies.

Cryptographic Fundamentals: Principles and Algorithms

Introduction: Basic objectives of cryptography, secret-key and public-key cryptography, Block ciphers: Modes of operation, DES and its variants, AES, linear and differential cryptanalysis, stream ciphers, message digest algorithms: properties of hash functions, MD5 and SHA-1, keyed hash functions, attacks on hash functions.

Cryptography and Number Theory Fundamentals

Modular arithmetic, gcd, primality testing, Chinese remainder theorem, finite fields. Intractable problems: Integer factorization problem, RSA problem, discrete logarithm problem, DiffieHellman problem, Publickey encryption: RSA, Elliptic curve cryptography. Key exchange: Diffie-Hellman algorithms. Digital signatures: RSA, DSS, DSA, ECDSA, blind signatures, threshold cryptography, key management.

Advanced Network Security and Authentication

Network Security – Electronic Mail Security- Pretty Good Privacy – S/MIME – IP security – overview and architecture – authentication header – encapsulating security payload – combing security associations – web security requirements Secure Socket Layer and Transport Layer Security – secure electronic transactions, Authentication applications: X-509, Kerberos, RADIUS.

Wireless Network Security

Wireless network security - WEP, WPA2 (802.11i), security in Bluetooth Cybersecurity Basic Topics:1) Wireless Networks: Security and Privacy, Malware Analysis & Network Security, Web Application and Penetration Testing

References:

1. Stallings, W., "*Cryptography and network security: principles and practice*". 4th ed. Upper Saddle River: Prentice Hall, 2006.
2. Stallings, "*Network security essentials applications and standards*", Pearson education, 1999.
3. Menezes, A. J., Van Oorschot, P. C.; Vanstone, S. A., "*Handbook of applied cryptography*", Boca Ratón: CRC Press, 1997.
4. Stajano, F., "*Security for ubiquitous computing*, Chichester", John Wiley and Sons, 2002.

EE6432E ADVANCED ALGORITHMS AND DATA STRUCTURE ANALYSIS

Pre-requisites: **NIL**

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Describe algorithmic techniques such as brute force, greedy, and divide and conquer.

CO2: Apply advanced abstract data type (ADT) and data structures in solving real world problems.

CO3: Analyse complete algorithmic solution to a given problem effectively combining the fundamental data structures and algorithmic techniques

Foundations of Algorithms and Data Structures

Review of order notation & growth of functions, recurrences, probability distributions, Average case analysis of algorithms, Basic data structures such as stacks, queues, trees, graphs linked lists, and applications, priority queues.

Data Structures

Direct access tables and hash tables, hash functions and relates analysis, Binary Search trees and Operations, AVL Trees and balancing operations, R B Trees, properties, operations. Dynamic Graphs, Strings, Succinct. Dynamic optimality, Memory hierarchy.

Advanced Algorithms

Quick sort randomized version, searching in linear time, More graph algorithms – maximal independent sets, colouring vertex cover, introduction to perfect graphs.

Algorithmic Paradigms and Design

Algorithmic paradigms Greedy Strategy, Dynamic programming, Backtracking, Branch-and-Bound, Randomized algorithms. Generic programming methodology and algorithm design – microprogramming - ADC, Quantization, word length issues, floating point numbers, etc.

References:

1. H. S. Wilf, "*Algorithms and complexity*", Prentice hall, 1994
2. T. H. Cormen, C. E. Leiserson, R. L. Rivest, "*Introduction to Algorithms*", MIT press, 2009.

EE6433E INDUSTRIAL LOAD MODELLING AND CONTROL

Pre-requisites: **NIL**

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Analyze load control techniques in industries and its application.

CO2: Describe industrial processes using tools like LINDO and LINGO.

CO3: Apply load management technique to reduce the demand of electricity during peak time.

CO4: Analyze different energy saving opportunities in industries.

CO5: Apply the techniques of reactive power control and different power factor improvement methods.

Industrial Load Management and Pricing

Electric Energy Scenario-Demand Side Management-Industrial Load Management; Load Curves-Load Shaping Objectives-Methodologies-Barriers; Classification of Industrial Loads- Continuous and Batch processes -Load Modelling; Electricity pricing – Dynamic and spot pricing - Models.

Load Control and Optimization

Direct load control- Interruptible load control; Bottom up approach- scheduling- Formulation of load models - optimisation and control algorithms - Case studies; Reactive power management in industries-controls-power quality impacts-application of filters.

Cooling, Heating, and Load Profiling

Cooling and heating loads- load profiling- Modeling- Cool storage-Types-Control strategies-Optimal operation-Problem formulation- Case studies.

Captive Power and Integrated Load Management

Captive power units- Operating and control strategies- Power Pooling- Operation models; Energy Banking- Industrial Cogeneration; Selection of Schemes Optimal Operating Strategies-Peak load saving- Constraints-Problem formulation-Case study; Integrated Load management for Industries.

References:

1. C.O. Bjork, "*Industrial Load Management - Theory, Practice and Simulations*", Elsevier, the Netherlands,1989.
2. C.W. Gellings and S.N. Talukdar, "*Load management concepts*". IEEE Press, New York, 1986, pp. 3-28.
3. Various Authors, "*Demand side management – Alternatives*", IEEE Proceedings on DSM , Oct 1985
4. Y. Manichaikul and F.C. Schweppe, "*Physically based Industrial load*", IEEE Trans. on PAS, April 1981
5. H. G. Stoll, "*Least cost Electricity Utility Planning*", Wiley Interscience Publication, USA, 1989.
6. I.J.Nagarath and D.P.Kothari, "*Modern Power System Engineering*", Tata McGraw Hill publishers, New Delhi, 1995.
7. Richard E. Putman, "*Industrial energy systems: analysis, optimization, and control*", ASME Press, 2004

EE6434E INDUSTRIAL OPERATION AND CONTROL

Pre-requisites: **NIL**

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Describe common unit operations in process industries.
CO2: Develop understanding of important processes taking place selected case studies namely petrochemical industry, power plant industry and paper & pulp industry.
CO3: Analyse appropriate measurement techniques for selective processes.
CO4: Analyze the operation and challenges in integrated industrial processes.

Mechanical Operations in Process Industries
Transport of solid – General Characteristics of solids, Storage and conveying of solids: bunkers, silos, bins, and hoppers, transport of solids in bulk, conveyor selection, different types of conveyors. Estimation of particle size, Screening methods, and equipment. Adjusting particle size: methods of size reduction, classification of equipment, crushers, grinders. size enlargement- Principle of granulation, briquetting, palletization, and flocculation.

Mixing Operations
Mixing: mixing of powders. Separation: Electrostatic and magnetic separators, applications. Handling and mixing, size reduction & mechanical separations, Transport and flow of liquids, Mixing, and agitation: Mixing of liquids, selection of suitable mixers; Separation: Gravity settling, sedimentation, thickening, double cone classifier, centrifugal separation; Cyclones – Operation, equipment, control and applications, Membrane separation Process.

Combustion Process
Heat transfer, Single pass, and multi-pass heat exchangers, condensers, reboiler, the Combustion process in thermal power plant; Distillation: Binary distillation, Batch distillation, controls and operations, Heat exchange equipment, Theory of evaporation – single effect and multiple effect evaporators – Crystallization – nucleation and growth – classification of crystallizers. Drying: classification of Dryers, batch, and continuous dryers, dryers for solids and slurries and cooling Towers, Refrigeration.

Measurement and Control in Industry
Thermal power plant - Process flow diagram of Coal-fired thermal Power Plant, Coal pulverizer, Deaerator, Boiler drum, drum level control- Single, two, and three-element control, Super heater, and Turbines. Petro Chemical Industry - Process flow diagram, Gas oil separation in a production platform, wet gas processing, Catalytic Cracking unit, Catalytic reforming unit, Distillation Column, Alkylation, Isomerization, Paper and Pulp industry – Process flow diagram, Batch digester, Continuous sulfate digester.

References:

1. Balchan.J.G., and Mumme K.I., "*Process Control Structures and Applications*", Van Nostrand Reinhold Company, New York, 1988.
2. Warren L. McCabe, Julian C. Smith, and Peter Harriot, "*Unit Operations of Chemical Engineering"*, McGraw-Hill International Edition, New York, 6th ed., 2001.
3. Austin G.T and Shreeves, A.G.T., "*Chemical Process Industries*", McGraw–Hill International student, Singapore, 2016.
4. Liptak B.G., "*Instrument and Automation Engineers' Handbook: Process Measurement and Analysis*", 5th ed., CRC Press, 2016.
5. Andrew Williams, "*Applied instrumentation in the process industries*",3rd ed., 2007, Vol. 1 & 3, Gulf publishing company.
6. Krishnaswamy.K and Ponnibala.M., "*Power plant Instrumentation*, PHI learning Pvt, ltd, New delhi, 2011.
7. Luyben W.C., *Process Modelling, Simulation and Control for Chemical Engineers"*, McGraw-Hill International edition, USA, 2013.
8. James R.couper, Roy Penny, W., James R.Fair and Stanley M.Walas, "*Chemical Process Equipment Selection and Design"*, Gulf Professional Publishing, 2010.

ZZ6001E RESEARCH METHODOLOGY

Pre-requisites: NIL

L	T	P	O	C
2	0	0	4	2

Total Lecture sessions: 26

Course Outcomes:

CO1: Explain the basic concepts and types of research

CO2: Develop research design and techniques of data analysis

CO3: Develop critical thinking skills and enhanced writing skills

CO4: Apply qualitative and quantitative methods for data analysis and presentation

CO5: Implement healthy research practice, research ethics, and responsible scientific conduct

Exploring Research Inquisitiveness

Philosophy of Scientific Research, Role of Research Guide, Planning the Research Project, Research Process, Research Problem Identification and Formulation, Variables, Framework development, Research Design, Types of Research, Sampling, Measurement, Validity and Reliability, Survey, Designing Experiments, Research Proposal, Research Communication, Research Publication, Structuring a research paper, structuring thesis/ dissertation,

Research Plan and Path

Developing a Research Plan: Reviewing the literature- Referencing – Information sources – Information retrieval – Role of libraries in information retrieval – Tools for identifying literatures – Reading and understanding a research article – Critical thinking and logical reasoning; Framing the research hypotheses, Converting research Question into a Model; Data collection- Types of data-Dataset creation- Primary and Secondary data- Scales of measurement- Sources and collection of data- Processing and analysis of data-Understanding Data-statistical analysis, displaying of data-Data visualization-Data interpretation; Research design- Qualitative and Quantitative Research- Designing of experiments- Validation of experiments- Inferential statistics and result interpretation

Scientific Conduct and Ethical Practice

Plagiarism– Ethics of Research- Scientific Misconduct- Forms of Scientific Misconduct. Plagiarism, Unscientific practices in thesis work-Conduct in the workplace and interaction with peers – Intellectual property: IPR and patent registration, copyrights; Current trends – Usage and ethics of AI tools in scientific research.

References:

1. Leedy, P D, *Practical Research: Planning and Design*, USA: Pearson, Twelfth ed., 2018.
2. Krishnaswamy, K. N., Sivakumar, A. I., and Mathirajan, M., *Management Research Methodology*, Pearson Education, 2006.
3. Tony Greenfield and Sue Greener., *Research Methods for Postgraduates*, USA: John Wiley & Sons Ltd., Third ed., 2016.
4. John W. Creswell and J. David Creswell, *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*, USA: Sage Publications, Sixth ed., 2022.

MS6174E TECHNICAL COMMUNICATION AND WRITING

Pre-requisites: **NIL**

L	T	P	O	C
2	1	0	3	2

Total Lecture Sessions: 26

Course Outcomes:

CO1: Apply effective communication strategies for different professional and industry needs.

CO2: Collaborate on various writing projects for academic and technical purposes.

CO3: Combine attributes of critical thinking for improving technical documentation.

CO4: Adapt technical writing styles to different platforms.

Technical Communication

Process(es) and Types of Speaking and Writing for Professional Purposes - Technical Writing: Introduction, Definition, Scope and Characteristics - Audience Analysis - Conciseness and Coherences - Critical Thinking - Accuracy and Reliability - Ethical Consideration in Writing - Presentation Skills - Professional Grooming - Poster Presentations

Grammar, Punctuation and Stylistics

Constituent Structure of Sentences - Functional Roles of Elements in a Sentence - Thematic Structures and Interpretations - Clarity - Verb Tense and Mood - Active and Passive Structures - Reporting Verbs and Reported Tense - Formatting of Technical Documents - Incorporating Visuals Elements - Proofreading

Technical Documentation

Types of Technical Documents: Reports, Proposals, Cover Letters - Manuals and Instructions - Online Documentation - Product Documentation - Collaborative Writing: Tools and Software - Version Control Document Management - Self Editing, Peer Review and Feedback Processes

References:

1. Foley, M., & Hall, D., *Longman advanced learner's grammar, a self-study reference & practice book with answers*. Pearson Education Limited, 2018.
2. Gerson, S. J., & Gerson, S. M., *Technical writing: Process and product*, Pearson, 2009.
3. Kirkwood, H. M. A., & M., M. C. M. I., *Hallidays introduction to functional grammar* (4th ed.), Hodder Education, 2013.
4. Markel, M., *Technical Communication* (10th ed.). Palgrave Macmillan, 2012.
5. Tuhovsky, I., *Communication skills training: A practical guide to improving your social intelligence, presentation, Persuasion and public speaking skills,* Rupa Publications India, 2019.
6. Williams, R., *The Non-designer's Design Boo*k. Peachpit Press, 2014.

IE6001E ENTREPRENEURSHIP DEVELOPMENT

Pre-requisites: **NIL**

L	T	P	O	C
2	0	0	4	2

Total Lecture Sessions: 26

Course Outcomes:

CO1: Describe the various strategies and techniques used in business planning and scaling ventures.

CO2: Apply critical thinking and analytical skills to assess the feasibility and viability of business ideas.

CO3: Evaluate and select appropriate business models, financial strategies, marketing approaches, and operational plans for startup ventures.

CO4: Assess the performance and effectiveness of entrepreneurial strategies and actions through the use of relevant metrics and indicators.

Entrepreneurial Mindset and Opportunity Identification

Introduction to Entrepreneurship Development - Evolution of entrepreneurship, Entrepreneurial mindset, Economic development, Opportunity Recognition and Evaluation - Market gaps - Market potential, Feasibility analysis - Innovation and Creativity in Entrepreneurship - Innovation and entrepreneurship, Creativity techniques, Intellectual property management.

Business Planning and Execution

Business Model Development and Validation - Effective business models, Value proposition testing, Lean startup methodologies - Financial Management and Funding Strategies - Marketing and Sales Strategies - Market analysis, Marketing strategies, Sales techniques - Operations and Resource Management - Operational planning and management, Supply chain and logistics, Stream wise Case studies.

Growth and Scaling Strategies

Growth Strategies and Expansion - Sustainable growth strategies, Market expansion, Franchising and partnerships - Managing Entrepreneurial Risks and Challenges - Risk identification and mitigation, Crisis management, Ethical considerations - Leadership and Team Development - Stream wise Case studies.

References:

1. Kaplan, J. M., Warren, A. C., & Murthy V., *Patterns of entrepreneurship management.* John Wiley & Sons, 2022.
2. Kuratko, D. F., *Entrepreneurship: Theory, Process, and Practice*. Cengage learning.
3. Barringer, B. R., *Entrepreneurship: Successfully launching new ventures*, Pearson Education India, 2015.
4. Rajiv Shah, Zhijie Gao, Harini Mittal, *Innovation, Entrepreneurship, and the Economy in the US, China, and India,* Academic Press, 2014.
5. Sundar,K., *Entrepreneurship Development*, 2nd Ed., Vijaya Nichkol Imprints, Chennai, 2022.
6. E. Gordon,Dr. K. Natarajan., *Entrepreneurship Development*, 6th Ed, Himalya Publishers, Delhi, 2017.
7. Debasish Biswas, Chanchal Dey, *Entrepreneurship Development in India*, Taylor & Francis, 2021.