Course Description

Title: Digital Hardware Design **Code:**
L- T-P Scheme: 3-0-0 **Credit: 3**

Prerequisite: Students should be studied the courses: "Digital Circuit Design".

Objective:

The course shall provide the students with advanced knowledge in modern electronic design with the help of a hardware description language. After successful completion of the course the student shall be able to design and implement the digital hardware circuits. Also the students will verify, synthesize and implement a design written in VHDL.

Learning outcomes:

Course Outcome	Description
CO1	Outline basics of digital electronics with respect to their needs in the digital system design. Classification of digital systems and examples of their applications.
CO2	Description of the RTL micro-operations and their symbolic notions.
CO3	Development of Arithmetic Logic Unit (ALU) for various operations to be performed.
CO4	Identification and use of the combinational and sequential logic circuits and their use in system implementation.
CO5	Application of various synchronous and asynchronous circuits on a given assignment.
CO6	Demonstration and deployment of designs based on RTL using VHDL.

Course content:

Unit I: Introduction: Digital Design Flow, Hardware Design Environment- Design and Verification, EDA Tools, Simulation and Synthesis process.

Unit II: Register transfer logic (RTL): Inter register transfer, arithmetic, logic and shifter micro-operations, conditional control, ASM chart, data-path and control logic design.

Unit III: Processor logic design: Processor organization, arithmetic logic unit, design of ALU, overflow, arithmetic shift, design of multi-purpose accumulator.

Unit IV: Asynchronous Sequential Machine: Introduction to asynchronous sequential machine. Analysis of asynchronous circuits, flow table, race condition, primitive flow table, state reduction, state assignment and synthesis of asynchronous circuit. hazards.

Unit V: Arithmetic logic design: Ripple carry adder, carry look-ahead adder, carry select adder, carry save adder, parallel multiplier, sign multiplication, Baugh-Wooly multiplication algorithm, radix-4 Booth multiplication algorithm

Unit VI: RTL simulation: Package declaration for different data types, use of generate statement, VHDL coding of generic logic components for combinational logic circuits (multiplexer, decoder, parallel adder/ subtractor, ALU and multiplier) and sequential logic circuits (registers and accumulator).

Teaching Methodology:

This course is introduced to help students to understand the basics of Digital circuit and system design. Starting from frontend development, the student will slowly progress to become to other aspects of digital VLSI. Design skills that are helpful for an engineer. The entire course is based on: Fundamental and Designing, EDA tool & Technologies and brief idea of the digital hardware. Each section includes digital circuit designs to help a student to gain basic knowledge of digital systems.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1
Test-2	25 Marks	Based on Unit-2, Unit-3 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-4 to Unit-5 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	100 Marks	

Learning Resources:

Tutorials and lecture notes/slides on Digital Hardware Design (will be added from time to time): Digital copy will be available on the JUET server.

Text Books:

[1] M. Morris Mano: Digital Logic and Computer Design, Prentice Hall of India.

Reference Books:

[1] M. Morris Mano: Digital Design, Prentice Hall of India.
[2] Charls Roth: Fundamental of Logic Design.

Web References:

[1] https://swayam.gov.in

Journals References:

[1] IET Computers & Digital Techniques - IET Digital Library
[2] IEEE Transactions on Computers

Title: FPGA based System Design **Code:**
L-T Scheme: 3-0-0 **Credits: 3**

Prerequisite: Students must have already studied courses, "*VLSI Circuits & System Design*".

Course Objectives:

In this course the students will learn logic design and optimization techniques using FPGA, VHDL and Verilog design concepts, Combinational logic concepts, sequential VHDL processing and FPGA.

Learning Outcomes:

Course Outcome	Description
CO1	Outline various hardware description language with respect to their needs for the development of digital systems
CO2	Description of digital systems using HDL subprograms.
CO3	Development of HDL code for a given logic circuit in various modeling styles.
CO4	Identification and use of test bench to verify the functionality of design.
CO5	Application of digital systems design with HDL on a given assignment/ project.
CO6	Demonstration and deployment of the FPGA for a given combinational and sequential digital systems.

Course Content:

Unit-I: Introduction: Concepts of Hardware Description Languages, VHDL: objects, types and subtypes, operators, packages

Unit-II: Logic synthesis: Design cycle, types of synthesizers, design optimization techniques, technology mapping, design organization.

Unit-III: Combinational Logic: Design units, entities and architectures, simulation and synthesis model, signals and ports, simple signal assignments, conditional signal assignments, selected signal assignment.

Unit-IV: Sequential logic design: Processes, variables, sequential statements, Registers: Simulation and synthesis model of register, register templates, clock types, gated registers, resettable registers, simulation model of asynchronous reset, asynchronous reset templates, registered variables, FSM: Moore and Mealy machine modelling.

Unit-V: Hierarchy: components, component instances, component declaration, generate statements, Configuration specifications, default binding, binding process, component packages Functions, procedures, declaring subprograms, Test benches, verifying responses, printing response values, reading data files, Verilog, Overview of Digital Design with Verilog HDL,

Basic Concepts, Modules and Ports, Basics of -Gate-Level Modeling, Dataflow Modeling, Behavioral Modeling.

Unit-VI: FPGA: Introduction, Logic Block Architecture, Routing Architecture, Programmable, Interconnection, Design Flow, Xilinx Virtex-II , Artix-7 (Architecture), Boundary Scan, Programming FPGA's, Interface of FPGA board with input and output devices.

Teaching Methodology:

Lectures would cover the core theoretical and practical concepts that are explained in the text and reference materials with adequate examples. Lab sessions will have conceptual and logic building approach that would aid in strengthening the design principles and testing of Complex Digital systems on chip level.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1 and Unit-2
Test-2	25 Marks	Based on Unit-3 & Unit-4 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-5 to Unit-6 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	100 Marks	

Learning Resources:

Tutorials and lecture slides on FPGA based System Design (will be added from time to time): Digital copy will be available on the JUET server.

Text Books:

[1] Charles H. Roth, Digital System Design Using VHDL , Jr.,Thomson, (2008)2nd Ed.

[2] Bhaskar, J., A VHDL Primer, Pearson Education/ Prentice Hall (2006)3rd Ed.

Reference Books/Material:

[1] Ashenden, P., The Designer's Guide To VHDL, Elsevier (2008) 3rd Ed.

[2] David C. Black and Jack Donovan, SystemC: From the Ground Up, Springer, (2014) 2nd Ed.

[3] Rushton, A., VHDL for Logic Synthesis, Wiley (1998) 2ed.

[4] Samir Palnitkar, Verilog HDL: A Guide to Digital Design and Synthesis, Prentice Hall PTR (2003) 2nd Ed.

Web References:

[1] https://www.tutorialspoint.com/

[2] https://nptel.ac.in/

Journals References:

[1] IEEE Journal of digital system design

[2] IRE Transactions on Industrial Electronics

Title: IC Technology **Code:**
L- T-P Scheme: 3-0-0 **Credit: 3**

Prerequisite: Students should be studied the courses: "VLSI Design".

Objective:
The course shall provide the students with advanced knowledge in modern electronic design with the help of a hardware description language.

Learning outcomes:

Course Outcome	Description
CO1	Outline basics of IC technology with respect to their needs in the IC fabrication.
CO2	Description of the fabrication technologies.
CO3	Development of various lithography techniques
CO4	Progress of CMOS IC fabrication steps.
CO5	Application of various IC fab. techniques in MOS circuit design.

After successful completion of the course the student shall be able to know the IC fabrication techniques.

Course Content:
Unit-I: Introduction to IC Technology: Basic fabrication steps and their Importance. Environment of IC Technology: Concepts of Clean room and safety requirements, Concepts of Wafer cleaning processes and wet chemical etching techniques.
Unit-II: Impurity Incorporation: Solid State diffusion modeling and technology; Ion Implantation modeling, technology and damage annealing, characterization of Impurity profiles
Unit-III: Oxidation: Kinetics of Silicon dioxide growth both for thick, thin and ultra thin films, Oxidation technologies in VLSI and ULSI, Characterization of oxide films, High k and low k dielectrics for ULSI. Lithography: Photolithography, E-beam lithography and newer lithography techniques for VLSI/ULSI, Mask generation.
Unit-IV: Chemical Vapour Deposition Techniques: CVD techniques for deposition of poly-silicon, silicon dioxide, silicon nitride and metal films; Epitaxial growth of silicon: modeling and technology. Metal Film Deposition: Evaporation and sputtering techniques, Failure mechanisms in metal interconnects Multi-level metallization schemes.
Unit-V: Plasma and Rapid Thermal Processing: PECVD, Plasma etching and RIE techniques; RTP techniques for annealing, growth and deposition of various films for use in ULSI.

Teaching Methodology:

This course is introduced to help students to understand the basics of Semiconductor devices and IC fabrication technologies.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1
Test-2	25 Marks	Based on Unit-2, Unit-3 and around 30% from coverage of Test-1

Test-3	35 Marks	Based on Unit-4 to Unit-5 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	100 Marks	

Learning Resources:
Tutorials and lecture notes/slides on IC Technology (will be added from time to time): Digital copy will be available on the JUET server.

Text Books:

[1] S.M.Sze(2nd Edition)"VLSI Technology", McGraw Hill Companies Inc.

[2] C.Y. Chang and S.M.Sze (Ed), "ULSI Technology", McGraw Hill Companies Inc.

References Text Books:

[1] Stephena, Campbell, "The Science and Engineering of Microelectronic Fabrication", Second Edition, Oxford University Press.

[2] James D.Plummer, Michael D.Deal, "Silicon VLSI Technology" Pearson Education

Title: VLSI Verification and Testing **Code:**
L-T Scheme: 3-0-0 **Credits: 3**

Prerequisite: Students must have already studied courses, "*Digital Hardware Design*".

Course Objectives:
In this course the students will learn VLSI verification and testing methods.

Learning Outcomes:

Course Outcome	Description
CO1	Outline various VLSI testing and verification processes.
CO2	Description of various faults models.
CO3	Development of system testing models.
CO4	Design of verification techniques based on simulation
CO5	Application of VLSI testing and verification on a given assignment/ project.

Course Content:

Unit-I: Scope of testing and verification in VLSI design process. Issues in test and verification of complex chips, embedded cores and SOCs.
Unit-II: Fundamentals of VLSI testing. Fault models. Automatic test pattern generation. Design for testability. Scan design. Test interface and boundary scan.
Unit-III: System testing and test for SOCs. Idd_q testing. Delay fault testing. BIST for testing of logic and memories. Test automation.
Unit-IV: Design verification techniques based on simulation, analytical and formal approaches. Functional verification. Timing verification, Formal verification.
Unit-V: Basics of equivalence checking and model checking. Hardware emulation.

Teaching Methodology:
Lectures would cover the core theoretical and practical concepts that are explained in the text and reference materials with adequate examples.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1 and Unit-2
Test-2	25 Marks	Based on Unit-2 & Unit-3and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-4 to Unit-5 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	100 Marks	

Learning Resources:
Tutorials and lecture slides on VLSI verification and testing (will be added from time to time): Digital copy will be available on the JUET server.

Text Books:

[1] M. L. Bushnell and V.D. Agrawal, Essentials of Electronic Testing for Digital Memory
[2] and Mixed Signal VLSI Circuits, Springer, 2005
[3] H. Fujiwara, Logic Testing and Design for Testability, MIT Press, 1985
[4] M. Abramovici, M. Breuer, and A. Friedman, Digital System Testing and Testable Design, IEEE Press, 1994

References Books:

[1] M. Huth and M. Ryan, Logic in Computer Science, Cambridge Univ. Press, 2004.
[2] T. Kropf, Introduction to Formal Hardware Verification, Springer Verilog, 2000

Title: Emerging Technology beyond 5G **Code:**
L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied courses, "*Wireless Communication*" and "Mobile Communication".

Objective:
The objective of the "Emerging Technology beyond 5G" syllabus is designed to provide students with a deep and comprehensive understanding of the advanced telecommunications technologies that drive the development and implementation of 5G networks and beyond. Here's a detailed breakdown of the course objectives:

a) To Understand Comprehensive 5G and Beyond Technologies
b) To Analyze and Implement Advanced Networking Solutions
c) To Prepare for Future Technological Shifts in Telecommunications
d) To Cultivate a Practical Understanding through Real-World Applications

Learning Outcomes:

Course Outcome	Description
CO1	Understanding the evolution from GSM to LTE-Advanced Pro and the role of 5G in enhancing mobile broadband capabilities.
CO2	Develop the capability to critically analyze the architectural nuances of the 5G core network, including the use of service-based interfaces, data transport mechanisms, and the complexities of non-3GPP access
CO3	Design capability and assess RAN areas, tracking areas, and the integration of 5G with legacy 4G technologies.
CO4	Address and propose the implications of radio propagation issues like diffraction, multipath fading, and coherence.
CO5	Master digital signal processing techniques specific to 5G technologies, including modulation and demodulation processes, OFDM, and adaptive modulation strategies.

Course Content:
Unit-1: Introduction of 5G,Architecture of a Mobile Telecommunication System, High-level Architecture, Internal Architecture of the Mobile, Coverage and Capacity, Architecture of the Core Network, Communication Protocols, Global System for Mobile Communications (GSM), Long-term Evolution (LTE), LTE-Advanced, LTE-Advanced Pro, 5G Research Projects, Enhanced Mobile Broadband, Network Operation, Technologies for 5G, Network Function Virtualization, Software-defined Networking, The 3GPP Specifications for 5G, Architecture of 5G, High-level Architecture.

Unit-II: Architecture of the Core Network
Release 8 Architecture, The 5G Core Network, Representation Using Reference Points, Representation Using Service-based Interfaces, Data Transport, Roaming Architectures, Data Storage Architectures, Non-3GPP Access to the 5G Core, Network Areas, Slices and Identities AMF Areas and Identities, UE Identities and registration areas, Non-3GPP Access, Signalling Protocols, Signalling Protocol Architecture, Example Signalling Procedures.

Unit-III: Architecture of the Radio Access Network

The Next-generation Node B, Carrier Aggregation, The Next-generation Node B, Deployment Options, Multi-radio Dual Connectivity, Options 1 and 3 – EPC, E-UTRAN and MeNB, Options

5 and 7 – 5GC, NG-RAN and MeNB, Options 2 and 4 – 5GC, NG-RAN and MgNB, Data Transport, Tracking Areas, RAN Areas, Cell Identities, 5G State Diagram, Interworking with 4G, Signalling Protocols, Signalling Protocol Architecture.

Unit-IV: Spectrum, Antennas and Propagation

Radio Spectrum, RadioWaves, Spectrum Allocations for 5G, Antenna Arrays for 5G, Radio Propagation Issues for Millimetre Waves, Diffraction and Reflection, Penetration Losses, Foliage Losses, Multipath, Fading and Coherence, Angular Spread and Coherence Distance, Doppler Spread and Coherence Time, Delay Spread and Coherence Bandwidth, Channel Reciprocity.

Unit-V: Digital Signal Processing

Modulation and Demodulation, Carrier Signal, Modulation and Demodulation Process, Channel Estimation, Adaptive Modulation, Multiplexing and Multiple Access, FDD and TDD Modes, Orthogonal Frequency Division Multiple Access, Subcarriers, OFDM Transmitters and Receivers, Inter-symbol Interference and the Cyclic Prefix, Signal-processing Issues for 5G, Power Consumption, Timing Jitter and Phase Noise, Choice of Symbol Duration and Subcarrier Spacing, Error Management, Hybrid ARQ.

Unit- VI: Architecture of the 5G New Radio

Air Interface Protocol Stack, 5G Protocol Stack, Channels and Signals, Information Flows, Frequency Bands and Combinations, Frequency Domain Structure, Transmission Bandwidth Configuration, Global and Channel Frequency Rasters, Common Resource Blocks, Virtual and Physical Resource Blocks, Time Domain Structure, Frame Structure, Timing Advance, TDD Configurations, Slot Format Combinations, Multiple Antennas, Relationships Between Antenna Ports, Data Transmission.

Teaching Methodology:

Regular lectures will be conducted to provide theoretical knowledge and foundational concepts related to 5G and beyond. Lectures will include multimedia presentations to illustrate complex network architectures, signal processing techniques, and future technology forecasts. Each lecture will be supplemented by interactive discussion sessions where students can ask questions, share ideas, and delve deeper into challenging concepts. This will encourage critical thinking and help clarify difficult topics in real-time. Regular quizzes and exams will be conducted to assess and reinforce learning. These assessments will also help students to stay engaged and keep pace with the course.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1, Unit-2 & Unit-3
Test-2	25 Marks	Based on Unit-4 & Unit-5 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-6 to Unit-8 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	100 Marks	

Learning Resources:

All the lecture material and relevant documents on “Emerging Technology beyond 5G” will be added on the JUET server (time to time).

Books and References:

5G Mobile and Wireless Communications Technology Afif Osseiran, Jose F. Monserrat, Patrick Marsch Cambridge University Press Second Edition 2011.
5G NR: The Next Generation Wireless Access Technology Erik Dahlman, Stefan Parkvall, Johan Sko¨ld Elsevier First Edition 2016.
Fundamentals of 5G Mobile Networks Jonathan Rodriguez Wiley First Edition.

Web References:

https://www.qualcomm.com/5g/what-is-5g
https://link.springer.com/book/10.1007/978-3-319-34208-5
https://www.sciencedirect.com/topics/computer-science/5g-mobile-communication
https://5gmf.jp/en/about-5g/

Journals References:

Y. Kim et al., "Feasibility of Mobile Cellular Communications at Millimeter Wave Frequency," in IEEE Journal of Selected Topics in Signal Processing, vol. 10, no. 3, pp. 589-599, April 2016, doi: 10.1109/JSTSP.2016.2520901.
O. O. Erunkulu, A. M. Zungeru, C. K. Lebekwe, M. Mosalaosi and J. M. Chuma, "5G Mobile Communication Applications: A Survey and Comparison of Use Cases," in IEEE Access, vol. 9, pp. 97251-97295, 2021, doi: 10.1109/ACCESS.2021.3093213.
Z. Wei et al., "5G PRS-Based Sensing: A Sensing Reference Signal Approach for Joint Sensing and Communication System," in IEEE Transactions on Vehicular Technology, vol. 72, no. 3, pp. 3250-3263, March 2023, doi: 10.1109/TVT.2022.3215159.
J. Navarro-Ortiz, P. Romero-Diaz, S. Sendra, P. Ameigeiras, J. J. Ramos-Munoz and J. M. Lopez-Soler, "A Survey on 5G Usage Scenarios and Traffic Models," in IEEE Communications Surveys & Tutorials, vol. 22, no. 2, pp. 905-929, Secondquarter 2020, doi: 10.1109/COMST.2020.2971781.
T. Norp, "5G Requirements and Key Performance Indicators," in Journal of ICT Standardization, vol. 6, no. 1-2, pp. 15-30, 2018, doi: 10.13052/jicts2245-800X.612.
A. Ghosh, A. Maeder, M. Baker and D. Chandramouli, "5G Evolution: A View on 5G Cellular Technology Beyond 3GPP Release 15," in IEEE Access, vol. 7, pp. 127639-127651, 2019, doi: 10.1109/ACCESS.2019.2939938.

Title: Green Communication Technology **Code:**
L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied courses, "*Wireless Communication"* and "Mobile Communication".

Objective:
The objective of this course is to provide students with a comprehensive understanding of IoT devices and energy challenges in Human Activity Recognition (HAR). Students will explore different types of IoT devices, advanced machine learning techniques for activity recognition, and various energy harvesting methods such as solar, kinetic, thermal, and RF waves. The course will also cover the use of energy harvesters as sensors and the design of systems for simultaneous sensing and energy harvesting, illustrated through practical case studies and performance evaluations.

Learning Outcomes:

Course Outcome	Description
CO1	Describe the various types of IoT devices, including implantable, wearable, and environmental sensors, and explain the energy challenges associated with Human Activity Recognition (HAR).
CO2	Utilize advanced machine learning techniques for HAR, including data acquisition, preprocessing, segmentation, feature extraction, model training, testing, and evaluation metrics, using relevant datasets.
CO3	Evaluate different energy harvesting techniques for IoT sensors, such as solar, kinetic, thermal, and RF waves, and analyze their effectiveness in various scenarios.
CO4	Assess the application of kinetic, solar, thermal, and RF energy harvesters as sensors through case studies on step count, audio signal detection, activity recognition, and transport mode detection.
CO5	Design and develop systems for simultaneous sensing and energy harvesting, considering detailed system design, hardware, and experimental setups, and perform comprehensive performance evaluations through practical case studies.

Unit I: IoT Devices and Energy Challenges for HAR, Types of IoT devices: Implantable, Wearable, Environmental, Energy challenges in IoT for HAR, Overview of research motivation and book organization.
Unit II: Advanced Techniques in Activity Recognition using IoT Mechanisms and wearable sensors for HAR, Deep dive into machine learning techniques for HAR: Data acquisition, preprocessing, segmentation, feature extraction, model training, testing, and evaluation metrics, Datasets for Developing and Evaluating HAR Algorithms.
Unit III: Energy Harvesting Techniques for IoT Sensors
Detailed exploration of energy harvesting modes: Solar, Kinetic, Thermal, RF Waves, Kinetic and Solar Energy Harvesting circuits, Operation of KEH transducer at MPP, Solar energy harvesting, circuits.
Unit IV: Utilizing Energy Harvesters as Sensors
Application of KEH, SEH, TEH, and RFEH as sensors, Case studies on step count, audio signal detection, activity recognition, transport mode detection.
Unit V: Simultaneous Sensing and Energy Harvesting in IoT System architecture and challenges for simultaneous sensing and energy harvesting, Detailed system design considerations, including hardware designs and experimental setups, Case study on transport mode detection and comprehensive performance evaluation.
Teaching Methodology:

The teaching methodology for this course includes interactive lectures to explain core concepts and energy challenges in IoT for HAR. Hands-on material will be provided for IoT devices, machine learning techniques, and energy harvesting methods. Lectures will foster problem-solving ability allowing students to design and evaluate HAR systems. Case studies will connect theoretical knowledge to real-world applications, demonstrating the use of energy harvesters as sensors. Continuous feedback will enhance learning and provide insights into cutting-edge developments.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1, Unit-2 & Unit-3
Test-2	25 Marks	Based on Unit-4 & Unit-5 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-6 to Unit-8 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	100 Marks	

Learning Resources:

All the lecture material and relevant documents on “Green Communication Technology” will be added on the JUET server (time to time).

Books and References:

[1] M. M. Sandhu, S. Khalifa, M. Portmann, and R. Jurdak, *Self-Powered Internet of Things: How Energy Harvesters Can Enable Energy-Positive Sensing, Processing, and Communication*. Cham, Switzerland: Springer Nature, 2023, doi: 10.1007/978-3-031-27685-9.

A. J. Sguarezi Filho, R. V. Jacomini, C. E. Capovilla, and I. R. S. Casella, Eds., *Smart Grids: Renewable Energy*. Cham, Switzerland: Springer Nature, 2022, doi: 10.1007/978-3-030-98944-9.

[2] R. Buyya and A. V. Dastjerdi, Internet of Things: Principles and Paradigms. San Francisco, CA, USA: Morgan Kaufmann, 2016.

[3] J. Soldatos, Machine Learning for the Internet of Things: Including IoT Architecture, Data Analytics, and Machine Learning Techniques. O'Reilly Media, 2019.

[4] S. Beeby and N. White, Energy Harvesting for Autonomous Systems. Norwood, MA, USA: Artech House, 2010.

[5] M. A. Labrador and O. D. Lara Yejas, Human Activity Recognition: Using Wearable Sensors and Smartphones. Boca Raton, FL, USA: CRC Press, 2013.

Web References:

[1] https://www.sciencedirect.com/topics/computer-science/green-communication

[2] https://www.computer.org/publications/tech-news/trends/power-of-green-communication/

[3] https://www.routledge.com/Green-Communication-Technologies-for-Future-Networks-An-Energy-Efficient-Perspective/Kaur-Srivastava/p/book/9781032206301

[4] https://digital-library.theiet.org/content/books/te/pbte091e

[5] https://www.comsoc.org/publications/journals/ieee-tgcn/cfp/green-communication-and-computing-technologies-6g-networks

Journals References:

[1] M. M. Mowla, I. Ahmad, D. Habibi and Q. V. Phung, "A Green Communication Model for 5G Systems," in IEEE Transactions on Green Communications and Networking, vol. 1, no. 3, pp. 264-280, Sept. 2017, doi: 10.1109/TGCN.2017.2700855.

[2] U. S. Toro, K. Wu and V. C. M. Leung, "Backscatter Wireless Communications and Sensing in Green Internet of Things," in IEEE Transactions on Green Communications and Networking, vol. 6, no. 1, pp. 37-55, March 2022, doi: 10.1109/TGCN.2021.3095792.

[3] F. K. Shaikh, S. Zeadally and E. Exposito, "Enabling Technologies for Green Internet of Things," in IEEE Systems Journal, vol. 11, no. 2, pp. 983-994, June 2017, doi: 10.1109/JSYST.2015.2415194.

[4] S. P. Raja, "Green Computing: A Future Perspective and the Operational Analysis of a Data Center," in IEEE Transactions on Computational Social Systems, vol. 9, no. 2, pp. 650-656, April 2022, doi: 10.1109/TCSS.2021.3093702.

[5] Abrol and R. K. Jha, "Power Optimization in 5G Networks: A Step Towards GrEEn Communication," in IEEE Access, vol. 4, pp. 1355-1374, 2016, doi: 10.1109/ACCESS.2016.2549641.

Title: Machine Learning for communication systems **Code:**
L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied courses, "*Neural Networks*", "*Mobile Communication"* and "Mobile Communication".

Objective:

The objective of this course is to equip students with a comprehensive understanding of the principles, methodologies, and applications of machine learning in communication systems. By the end of the course, students will be able to Understand Fundamental Concepts, Explore ML Techniques, Analyze Communication Systems, Design and Implement Algorithms, Optimize Network Performance.

Learning Outcomes:

Course Outcome	Description
CO1	Implement and Analyze Machine Learning Algorithms and demonstrate proficiency in implementing machine learning algorithms, understanding ML architecture, and applying them to real-world scenarios.
CO2	Assess the components, architectures, and applications of cognitive computing systems.
CO3	Apply Advanced Machine Learning Techniques in Wireless Networks including deep reinforcement learning, to optimize wireless communication systems.
CO4	Design and evaluate smart communication systems using cognitive computing and AI, focusing on resource management in cognitive radios and advanced wireless signal processing for 5G networks.
CO5	Develop and implement effective spectrum sensing and allocation schemes for cognitive radio networks, analyzing various detection techniques and addressing challenges in spectrum allocation while predicting future advancements.

Unit-I: Machine Learning Architecture and Framework,Machine Learning Algorithms, ML Architecture Data Acquisition, Latest Application of Machine Learning, Image Identification, Sentiment Analysis, Speech Recognition, Author Identification and Prediction, Services of Social Media, Medical Services, Recommendation for Products and Services, Future of Machine Learning.

Unit-II: Cognitive Computing: Architecture, Technologies and Intelligent Applications
Introduction, Components of a Cognitive Computing System, Subjective Computing Versus Computerized Reasoning, Cognitive Architectures, Subjective Architectures and HCI, Cognitive Design and Evaluation. Cognitive Computing: Overview, The Future of Cognitive Computing.

Unit-III: Deep Reinforcement Learning for Wireless Network,Machine Learning to Deep Learning, Advance Machine Learning Techniques, Deep Reinforcement Learning (DRL), Applications of Machine Learning Models in Wireless Communication, Regression, KNN and SVM Models for Wireless, Bayesian Learning for Cognitive Radio, Deep Learning in Wireless Network, Deep Reinforcement Learning in Wireless Network.

Unit-IV: Cognitive Computing for Smart Communication,Cognitive Computing Evolution, Characteristics of Cognitive Computing, Basic Architecture, Resource Management Based on Cognitive Radios, Designing 5G Smart Communication with Cognitive Computing and AI, Advanced Wireless Signal Processing Based on Deep Learning, Applications of Cognition-Based Wireless Communication.

Unit-V: Spectrum Sensing and Allocation Schemes for Cognitive RadioFoundation and Principle of Cognitive Radio, Spectrum Sensing for Cognitive Radio Networks, Classification of Spectrum Sensing Techniques, Energy Detection, Matched Filter Detection, Cyclo-Stationary

Detection Euclidean Distance-Based Detection, Spectrum Allocation for Cognitive Radio Networks, Challenges in Spectrum Allocation, Future Scope in Spectrum Allocation.

Teaching Methodology:
Regular lectures will be conducted to provide theoretical knowledge and foundational concepts related to Machine learning for Communication systems. Weekly hands-on lab sessions will provide practical experience, allowing students to implement algorithms and work with tools like Python and MATLAB. Additionally, case studies and the review of recent research papers will help students connect theoretical knowledge with current industry practices.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1, Unit-2 & Unit-3
Test-2	25 Marks	Based on Unit-4 & Unit-5 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-6 to Unit-8 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	100 Marks	

Learning Resources:
All the lecture material and relevant documents on “Machine Learning for communication systems” will be added on the JUET server (time to time).

Books and References:

[1]Fa-Long Luo," Machine Learning for Future Wireless Communications", John Wiley and Sons, 2020.

[2]Ruisi He, Z Ding, “Applications of Machine Learning in Wireless Communications”, IET Telecommunication series 81.

[3]K. K. Singh, A. Singh, K. Cengiz, Dac-Nhuong Le, “Machine Learning and Cognitive Computing for Mobile Communications and Wireless Networks”, Wiley 2020.

Web References:

[1]https://www.comsoc.org/publications/best-readings/machine-learning-communications

[2]https://www.itu.int/dms_pub/itu-s/opb/journal/S-JOURNAL-ICTF.VOL1-2018-1-P06-PDF-E.pdf

[3]https://ieeexplore.ieee.org/document/8542764

[4]https://www.dhillon.ece.vt.edu/mlcourse.html

[5]https://digital-library.theiet.org/content/books/te/pbte081e

Journals References:

[1]J. Park et al., "Communication-Efficient and Distributed Learning Over Wireless Networks: Principles and Applications," in Proceedings of the IEEE, vol. 109, no. 5, pp. 796-819, May 2021, doi: 10.1109/JPROC.2021.3055679.

[2]O. Simeone, "A Very Brief Introduction to Machine Learning With Applications to Communication Systems," in IEEE Transactions on Cognitive Communications and Networking, vol. 4, no. 4, pp. 648-664, Dec. 2018, doi: 10.1109/TCCN.2018.2881442.

[3]D. Gündüz, P. de Kerret, N. D. Sidiropoulos, D. Gesbert, C. R. Murthy and M. van der Schaar, "Machine Learning in the Air," in IEEE Journal on Selected Areas in Communications, vol. 37, no. 10, pp. 2184-2199, Oct. 2019, doi: 10.1109/JSAC.2019.2933969.

[4]M. E. Morocho-Cayamcela, H. Lee and W. Lim, "Machine Learning for 5G/B5G Mobile and Wireless Communications: Potential, Limitations, and Future Directions," in IEEE Access, vol. 7, pp. 137184-137206, 2019, doi: 10.1109/ACCESS.2019.2942390.

[5]D. Li, Y. Xu, M. Zhao, J. Zhu and S. Zhang, "Knowledge-Driven Machine Learning and Applications in Wireless Communications," in IEEE Transactions on Cognitive Communications and Networking, vol. 8, no. 2, pp. 454-467, June 2022, doi: 10.1109/TCCN.2021.3128597.

[6]D. Adesina, C. -C. Hsieh, Y. E. Sagduyu and L. Qian, "Adversarial Machine Learning in Wireless Communications Using RF Data: A Review," in IEEE Communications Surveys & Tutorials, vol. 25, no. 1, pp. 77-100, Firstquarter 2023, doi: 10.1109/COMST.2022.3205184.

[7]J. Joung, "Machine Learning-Based Antenna Selection in Wireless Communications," in IEEE Communications Letters, vol. 20, no. 11, pp. 2241-2244, Nov. 2016, doi: 10.1109/LCOMM.2016.2594776.

Title: Data Analytics for 5G **Code:**
L-T-P scheme: 3-0-0 **Credit: 3**
Prerequisite: Students must have already studied courses, "*Neural Networks*", "*Machine Learning*" and "*Mobile Communication*".
Objective:
The objective of the "Data Analytics for 5G" course is to equip students with the knowledge to leverage data analytics for maximizing the potential of 5G technology. Students will understand digital transformation and industry ecosystems, and explore the capabilities of 5G standalone (SA) and network slicing. They will learn about mobile edge computing, operational efficiency, and sustainability improvements. The course also covers private network deployment, standardization, and practical applications, culminating in the development of tailored business models for 5G. This prepares students to apply data analytics effectively in various industry settings using 5G technology.
Learning Outcomes:

Course Outcome	Description
CO1	Examine the impact of digital technologies and 5G on various industries to identify new business opportunities arising from digital disruption, Industry 4.0, and evolving business models.
CO2	Assess how smart and connected products, along with APIs, transform industry ecosystems by enhancing collaboration and data sharing, and contribute to the rise of the digital platform economy.
CO3	Comprehend the evolution towards 5G standalone (SA), including its technical foundations and new capabilities, and explain the significance and applications of network slicing in various industries.
CO4	Utilize mobile edge computing in industrial 5G applications to address challenges and leverage 5G for operational efficiency and sustainability improvements.
CO5	Develop tailored business models for 5G private networks by analyzing deployment models, interpreting enterprise and vertical requirements, and optimizing techno-economic factors for effective implementation.

Unit I: New Data-Driven Business Opportunities
Digital Disruption of Industries: Understand the impact of digital technologies on various industries, Role of Industrial 5G in Digital Transformation: Explore how 5G technology facilitates digital transformation, Industry 4.0 and the Ongoing Industrial Revolution: Discuss the characteristics and impacts of the fourth industrial revolution, Business Model Disruption: Study how new technologies disrupt existing business models and lead to new opportunities.

Unit II: Smart & Connected Products with APIs Transforming Industry Ecosystems Industry Ecosystems and Digital Transformation: Analyze how digital ecosystems transform industries, Benefits of Collaboration and Data Sharing: Understand the importance of collaboration and data sharing in industry ecosystems, Digital Platforms and Platform Economy: Examine the rise of digital platforms and their economic impact, Types of API and API Value Chain: Learn about different types of APIs and their roles in digital ecosystems.

Unit III: New Capabilities of 5G SA and Network Slicing Evolution Toward 5G Standalone: Overview of the transition from non-standalone to standalone 5G, Technical Foundations and New Capabilities: Understand the technical underpinnings and new features of 5G SA, Network

Slicing and Its Importance: Explore the concept of network slicing and its applications in various industries.

Unit IV: Mobile Edge and Real-Time Data-Driven Innovations
Mobile Edge Computing and Industrial 5G: Discover how mobile edge computing complements 5G in industrial applications, Challenges and Opportunities in Industry: Examine the challenges industries face and how they can leverage 5G for solutions, Operational and Sustainability Benefits: Discuss how 5G can improve operational efficiency and sustainability.

Unit V: Private Networks and Their Deployment in Industry
Private Networks Introduction and Standardization: Learn about the concept, significance, and standards of private networks, Deployment Models and Implementation Aspects: Understand different deployment models and key considerations for implementation, Case Studies and Practical Applications: Review case studies of private network implementation in various sectors.
Unit VI: Private Network Guidelines for Industry Verticals: Introduction to private networks and their significance, Network Deployment: Examination of SNSP and PNI-NPN deployment strategies, Deployment Models: Analysis of pros and cons for different deployment models, Techno-economic Optimization: Understanding techno-economic factors and optimization, Requirement Interpretation: Interpretation and assessment of enterprise and vertical requirements, Business Model Development: Developing business models tailored for 5G private networks.

Teaching Methodology:

The teaching methodology for "Data Analytics for 5G" integrates a blend of interactive lectures, and real-world case studies to ensure comprehensive understanding and practical application. Lectures will incorporate multimedia presentations and Q&A sessions to clarify complex concepts and engage students actively. Hands-on material will be provided for practical experience with data analytics tools and techniques relevant to 5G technologies. Case studies will link theoretical knowledge to industry practices, demonstrating the impact of 5G and data analytics on business models and industry ecosystems. Continuous formative feedback will further enhance learning; ensuring students are well-prepared to apply data analytics in the context of 5G technology.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1, Unit-2 & Unit-3
Test-2	25 Marks	Based on Unit-4 & Unit-5 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-6 to Unit-8 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	100 Marks	

Learning Resources:
All the lecture material and relevant documents on “Data Analytics for 5G” will be added on the JUET server (time to time).

Books and References:
[1]Alcardo Barakabitze; Andrew Hines, "5G Network Management for Big Data Streaming using Machine Learning," in Multimedia Streaming in SDN/NFV and 5G Networks: Machine

Learning for Managing Big Data Streaming , IEEE, 2023, pp.19-33, doi: 10.1002/9781119800828.ch2.

[2]Joseph Hoy, "3GPP Network Types," in Forensic Radio Survey Techniques for Cell Site Analysis , Wiley, 2024, pp.91-156, doi: 10.1002/9781394197200.ch5.

[3]Chamitha de Alwis; Quoc-Viet Pham; Madhusanka Liyanage, "Security and Privacy of 6G," in 6G Frontiers: Towards Future Wireless Systems , IEEE, 2023, pp.115-149, doi: 10.1002/9781119862321.ch10.

Web References:

[1] https://www.ericsson.com/en/core-network/5g-core/network-data-analytics-function

[2] https://www.mpirical.com/blog/5g-network-data-analytics

[3] https://www.thalesgroup.com/en/markets/digital-identity-and-security/mobile/5g-data

[4] https://futurenetworks.ieee.org/images/files/pdf/applications/Data-Analytics-in-5G-Applications030518.pdf

[5] https://www.sandvine.com/blog/network-data-analytics-function-in-5g-automated-analytics-where-you-need-it

[6] Journals References:

[7] B. Ma, W. Guo and J. Zhang, "A Survey of Online Data-Driven Proactive 5G Network Optimisation Using Machine Learning," in IEEE Access, vol. 8, pp. 35606-35637, 2020, doi: 10.1109/ACCESS.2020.2975004.

[8] E. Pateromichelakis et al., "End-to-End Data Analytics Framework for 5G Architecture," in IEEE Access, vol. 7, pp. 40295-40312, 2019, doi: 10.1109/ACCESS.2019.2902984.

[9] J. Huang et al., "A Big Data Enabled Channel Model for 5G Wireless Communication Systems," in IEEE Transactions on Big Data, vol. 6, no. 2, pp. 211-222, 1 June 2020, doi: 10.1109/TBDATA.2018.2884489.

[10] M. Ramachandran, T. Archana, V. Deepika, A. A. Kumar and K. M. Sivalingam, "5G Network Management System With Machine Learning Based Analytics," in IEEE Access, vol. 10, pp. 73610-73622, 2022, doi: 10.1109/ACCESS.2022.3190372.

Title: Internet of Things **Code:**
L-T-P Scheme: 3-0-0 **Credit: 3**
Prerequisite: Students must have already studied courses, "Measurement & Instrumentation".
Objective:
Understand the Internet of Things (IoT) concept and possible future trends.
Review the various network protocols & end devices used in IoT.
Learning outcomes:

Course Outcome	Description
CO1	Familiarization with different physical device related to IoT
CO2	Understand the IoT levels and methodology
CO3	Apply the programming tools required in IoT
CO4	Analyze the various architectures and protocols of IoT
CO5	Design and implement IoT technologies, solutions, and applications

Course Contents:
Unit-I: Fundamentals: IoT definition, Internet of Everything (IoE), characteristics, conceptual framework, technology behind IoT, application, challenges, Machine-to-Machine (M2M), comparison.
Unit-II: Sensors and Actuators: Principles, classification, characteristics, analog and digital sensor, electric and electronic sensors, resistive, capacitive and inductive type displacement sensor etc. mechanical sensor, pneumatic and hydraulic, hall sensors, ultrasonic sensor, IR sensor, temperature and humidity Sensors, digital switch, Electro-Mechanical switches, Actuator concepts, types, actuator performance criteria and selection, fluidic actuators, piezo-electric actuators.
Unit-III: Architecture and Protocol: IoT Levels, IoT Design methodology, Functional View, Information View, Deployment and Operational View, Other relevant architectural views. Protocol classification, Message Queue Telemetry Transport (MQTT), Extensible Messaging and Presence Protocol (XMPP), Advanced Message Queuing Protocol (AMQP), Constrained Application Protocol (CoAP), comparison.
Unit-IV: IoT End Devices: Arduino uno, Raspberry pi, technical specification, operating system, Interfaces, Intel Edison & Intel Galileo board, pcduino, beagle black and cubieboard, Programming.
Unit-V: Domain specific applications: Home automation, Smart cities, Smart irrigation, Green house control, Weather monitoring, River flood detection, Smart grids, Machine diagnosis and prognosis, Health monitoring, Smart Perishable Tracking, Smart warehouse, Smart driver assistance system etc.

Teaching Methodology:
Lectures would be interactive and it would cover the core concepts that are explained in the text and reference materials with adequate examples.
Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15	Based on Unit-1 and Unit-2
Test-2	25	Based on Unit-2 , Unit-3 and around 30% from coverage of Test-1
Test-3	35	Based on Unit-4, Unit-5 and around 30% from coverage of Test-2
Assignment	10	
Tutorials	5	

Quiz	5	
Attendance	5	
Total	100	

Text Books:

[1]Bahga A. and Madisetti V., "Internet of Things-A Hands-on- Approach", 1st Edi., VPT, 2014.

[2]D. Patranabis, "Sensors and Transducers", PHI Learning Private Limited.

[3]Srinivasa K G ,Siddesh G. M. and Hanumantha R. R., "Internet of Things", 2nd Edi. Cen. Edu., 2019.

[4]Reference Books:

[5]Kamal R., "Internet of Things", 2nd Edi., McGraw-Hill Education, 2014.

[6]Julian W.Gardner and Vijay K Varadhan, "Microsensors, MEMS and Smart Devices", John Wiley & sons, 2001.

[7]Shriram K V., Abhishek S N. and Sundram RMD, "Internet of Things", 1st Edi., John Wiley & Sons,2019.

Web References:

[1] https://archive.nptel.ac.in/courses/106/105/106105166/

[2] https://www.edureka.co

Journals References:

[1] https://ieee-iotj.org/

[2] https://www.sciencedirect.com/journal/internet-of-things

Title: Artificial Intelligence of Things **Code:**
L-T-P Scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied courses, "Machine Learning".
Objective:

a) To learn the fundamentals concepts and principles of AI empowered IoT.
b) To develop an IoT systems and apply to real-world applications.

Learning outcomes:

Course Outcome	Description
CO1	Review the basics of artificial intelligence
CO2	Understand the fundamental concepts and challenges in AIoT
CO3	Apply data analytics and networking in IoT systems
CO4	Visualize IoT data-creating dashboard
CO5	Develop AIoT systems and apply to real-world applications

Course Contents:
Unit-I: AI Review: Basics of Artificial Intelligence, Moore's law in context of AI, Need of fast computational resources, Hardware for training, Architectural Challenges for Training, Memory Challenges, Floating point accuracy.
Unit-II: Introduction to AIoT: Concepts and issues, Technical architecture, Technologies, Application segments, Cloud and Edge based, Challenges of AI in networks for IoT, Distributed intelligence at the edge of IoT systems , edge computing, block chain, etc., Robotics for AIoT.
Unit III: IoT Clouds and Computing: Apache Hadoop, Map Reduce model, Hadoop YARN. Python Packages for IoT, Amazon EC2, Autoscaling, S3, RDS, DynamoDB and MapReduce IoT Physical Servers –Cloud Storage Models, Communication APIs. Chef, Puppet, NETCONF-YANG.
Unit-IV: Artificial Intelligence and Data Analytics: AI for IoT data analytics and automation, Application of CPS in Machine tools, Digital production, Cyber Physical system Intelligence, Evaluation of Workforce and Human Machine Interaction: Worker and CPS, Strategies to support user intervention.
Unit-V: Visualization and Dashboard: Designing visual analysis for IoT data-creating dashboard– creating and visualizing alerts–basics of geo-spatial analytics-vector based methods-raster based methods- storage of geo-spatial data-processing of geo spatial data, Anomaly detection forecasting, Case study: pollution reporting problem.

Teaching Methodology:
Lectures would be interactive and it would cover the core concepts that are explained in the text and reference materials with adequate examples.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15	Based on Unit-1 & Unit-2
Test-2	25	Based on Unit-2, Unit-3 and around 30% from coverage of Test-1
Test-3	35	Based on Unit-4, Unit-5 and around 30% from coverage of Test-2
Assignment	10	
Tutorials	5	
Quiz	5	

Attendance	5	
Total	100	

Text Books:

[1] Francis DaCosta, "Rethinking the Internet of Things", Apress Berkeley,2014.

[2] Kai Hwang and Min Chen. "Big-Data Analytics for Cloud, IoT and Cognitive Computing", Wiley 2017.

[3] Amita Kapoor, "Hands-On Artificial Intelligence for IoT: Expert machine learning and deep learning techniques for developing smarter IoT systems", Packt Publishing Ltd. 2018.

Reference Books:

[1] Fadi AI-Turjman "AIoT Innovation", Springer. 2020

[2] Eugene Chang, "The Future of Artificial Intelligence, the Internet of Things, and Blockchain". Amazon. 2019.

Web References:

[1] https://viso.ai/edge-ai/artificial-intelligence-of-things-aiot/

[2] https://www.techtarget.com/iotagenda/definition/Artificial-Intelligence-of-Things-AIoT

Journals References:

[1] https://www.jair.org/index.php/jair

[2] https://jisajournal.springeropen.com/about/new-content-item

Title: Industrial Internet of Things **Code:**
L-T-P Scheme: 3-0-0 **Credit: 3**
Prerequisite: Students must have already studied courses, "Artificial Intelligence of Things".
Objective:

a) Understand key skills employed in the IIoT & IoRT space building applications.
b) Design suitable network architecture and use appropriate learning algorithm.

Learning outcomes:

Course Outcome	Description
CO1	Understand the working of different sensors
CO2	Analyze the various architectures and protocols of IIoT
CO3	Demonstrate cyber physical and cyber manufacturing systems
CO4	Describe Architectural design patterns for IIoT
CO5	Analyze Internet of Robotics Things (IoRT)

Course Contents:
Unit-I: Understanding IIoT: Definition, Information Next Generation Sensors, Sensor's calibration and validate sensor measurements, placement of IoT devices, sensors, low-cost communication system design, Top application areas include manufacturing etc.
Unit-II: Methodology: Top operating systems used in IIoT deployments, networking and wireless communication protocols used in IIoT deployments. Smart Remote Monitoring Unit, components of monitoring system, control and management, Wireless Sensor Network (WSN).
Unit-III: IIoT Modeling: Cyber Manufacturing Systems(CMS), Application map for Industrial Cyber Physical Systems (CPS), Cyber Physical Electronics production, Modeling, Model based engineering of supervisory controllers for cyber physical systems, formal verification of system, components, Evaluation model for assessments of cyber physical production systems.
Unit-IV: Architectural Design Pattern: CPS-based manufacturing and Industries 4.0., Integration of Knowledge base data base and machine vision, Interoperability in Smart Automation, Enhancing Resiliency in Production Facilities through CPS. Communication and Networking of IIoT
Unit-V: Application of IIoT: Smart Metering, e-Health Body Area Networks, City Automation, Automotive Applications, Smart Cards, Plant Automation, Real life examples of IIOT in Manufacturing Sector.
Unit-VI: Internet of Robotic Things (IoRT): Introduction to stationary and mobile robots, Brief introduction to localization, mapping, planning, and control of robotic systems; Introduction to cloud-enabled robotics; Applications of IIoT in robotics; Architectures for IoRT, Examples and case studies: Open issues and challenges.
Teaching Methodology:

Lectures would be interactive and it would cover the core concepts that are explained in the text and reference materials with adequate examples.
Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15	Based on Unit-1 & Unit-2
Test-2	25	Based on Unit-2, Unit-3 and around 30% from coverage of Test-1
Test-3	35	Based on Unit-4, Unit-5 and around 30% from coverage of Test-2

Assignment	10	
Tutorials	5	
Quiz	5	
Attendance	5	
Total	100	

Text Books:

[1] Alasdair Gilchrist, "Industry 4.0: The Industrial Internet of Things", Apress, 2016

[2] Sudip Misra,Chandana Roy,Anadarup Mukherjee, "Introduction to Industrial Internet of Things and Industry 4.0", CRC Press,2021

[3] Sabina Jeschke, Christian Brecher Houbing Song , Danda B. Rawat Editors "Industrial Internet of Things Cyber Manufacturing Systems"

Reference Books:

[1] Giacomo Veneri "Hands on Industrial Internet of Things", ,Antonio Capasso, Packt Press, 2018

[2] Ismail Butun ,"Industrial IoT Challenges, Design Principles, Applications, and Security".

[3] Mahmood, Zaigham, "The Internet of Things in the Industrial Sector,"

Web References:

[1] https://onlinecourses.nptel.ac.in/noc20_cs24/preview

[2] https://www.techtarget.com/iotagenda/definition/Industrial-Internet-of-Things-IIoT

Journals References:

[1] IEEE Transactions on Industrial Informatics

[2] Journal of Industrial Integration and Management

Title: Electronic Circuit Design **Code:**

L-T-P scheme: 3-0-0 **Credit: 3**

Course content

The course is organized around the phase of larger innovations in the design process of any electronic equipment. The students will get acquainted with a collaborating partner with a real-world problem. They will gain basic experience with relevant technology in order to design a system that meets the problem requirements.

Objective:

1. To organize the phase of larger innovations in the design process of any electronic equipment.
2. The students will get acquainted with a collaborating partner with a real-world problem.
3. Students will gain basic experience with relevant technology in order to design a system that meets the problem requirements.

Learning outcome:

Electronic Circuit Design	
Course Outcome	**Description**
CO1	Understand the D.C. power supply system
CO2	Design of SMPS and different power amplifier circuits
CO3	Analysis and evaluation of the sinusoidal oscillators for various frequencies
CO4	Design and analysis of various filters and their use in electronics and communication circuits.
CO5	Evaluate the frequency response to understand behaviour of electronic circuits

Unit-I: Design of Power supply system: Unregulated D.C. power supply system with rectifiers and filters. Design of emitter follower regulator, series regulators, overload protection circuits for regulators. Design of SMPS: Step up and step down.

Unit-II: Design of class A small signal amplifiers: Emitter follower, Darlington pair amplifiers with and without Bootstrapping, Two stage direct coupled amplifier. Design of class A, Class AB audio power amplifier with drivers.

Unit-III: Design of sinusoidal oscillators: OPAMP based Wein Bridge and Phase Shift oscillators with AGC circuits, Transistor based Hartley, Colpits and Crystal oscillators, Evaluation of figure of merit for all above oscillator circuits.

Unit-IV: Design of constant current sources, Design of function generators, Design of tuned amplifiers. Design of Butterworth, Chebyshev filters upto sixth order with VCVS and IGMF configuration.

Unit-V: ADC and DACs: Characteristics, interfacing, selecting an ADC. PCB design guidelines for reduced EMI.

Teaching Methodology:

The Students will be able to learn the electronic components, their operations and applications in communication circuits. They will also learn the designing of different electronic circuits.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1, Unit-2
Test-2	25 Marks	Based on Unit-2, 3 & Unit-4 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-4 and Unit-5 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and lecture slides on Electronic circuit design (will be added from time to time): Digital copy will be available on the JUET server

Text Books:

1. Operational amplifiers and linear integrated circuits, 3rd edition, Robert F.Coughlin, Prentice Hall International, Inc.

2. Ramakant A.Gayakwad: Op-Amps and Linear Integrated Circuits, Prentice Hall International, Inc.

Reference Books:

1. Regulated Power supply Handbook. Texas Instruments.

2. Monograph on Electronic circuit Design : Goyal & Khetan.

3. Intuitive analog circuit design : Mark.T Thompson; published by Elsevier.

4. PCB design guidelines for reduced EMI; Application notes

Web References:

[1]www.elprocus.com

[2] www.tutorialspoint.com

Journal References:

[1] IEEE transactions on circuits and systems

[2] IEEE transactions on electron devices

Title: Transducers Engineering **Code:**

L-T Scheme: 3-0-0 **Credit: 3**

Prerequisite: Not Applicable

Objectives:

1. To understand the principle of operation and the important characteristics of transducers commonly used in industry.
2. To familiarize with the selection criterion and installation process of transducers.
3. To design the appropriate signal conditioning circuit for specific measurement requirement.

Learning Outcomes:

Course Outcome	Description
CO1	Outline various types of transducers concerning their application in the industry.
CO2	Describe the operating principle of various types of the transducer.
CO3	Develop skills to select a transducer for a specific measurement requirement.
CO4	Identify and use various transducers and signal conditioning circuits used in the measurement process.
CO5	Analyze the performance of the transducer.
CO6	Demonstrate the application of various transducers.

Course Content:

Unit I: Transducer Fundamentals: Basic concept of Sensors and transducer, their comparisons, Classification of Transducer, Working of transducers used for measurement of Displacement- resistive, inductive and capacitive method, Linear and Angular Velocity moving coil and moving magnet method, various tachometers and stroboscope, Acceleration- seismic and peizo electric accelerometer, Working principle of Capacitive Transducer, Piezo-Electric Transducer, and LVDT.

Unit II: Strain and Temperature Measurement: Measurement Strain Gauges- strain measurement technique, resistance strain gauge and its types, Signal conditioning of strain gauges, Transducers for Temperature Measurement- non- electrical and electrical method, Bimetallic Thermometer, Resistance Thermometer like RTD, Thermistor and Thermocouple, Radiation and Optical Pyrometer.

Unit III: Pressure Measurement: Transducers for Measurement of Pressure: - Manometers types (like Single column, inclined, U-tube), Mechanical Types (Bourdon, bellows and diaphragm), Elastic Types transducers, Low Pressure measurement gauges (Ionization, McLeod etc.).

Unit IV: Flow Measurement: Transducers for Measurement of Flow: - Types of flow meters, Theory of variable head constant area meter and its types, theory of constant head variable area meter and its types, theory of variable head variable area meter and its types, Special flow meters- Electromagnetic, Hot wire Anemometer, Turbine meter and Ultrasonic flow meter.

Unit V: Miscellaneous Measurement and Smart Sensor: Transducer for Level Measurement: - direct and indirect method, resistive method, Ultrasonic, Capacitive and Gamma Ray level Gauges, Measurement of Humidity and Moisture- basic definitions, psychometric method, Smart sensors - Fiber optic sensors, MEMS – Nano sensors, and proximity sensor.

Teaching Methodology:

This course is introduced to familiarize the student with the various transducers used in the automation industry. Starting from the basic concepts, the student will gradually develop an understanding of practical setups used in the industry. The entire course is broken down into five units, such that each unit covers the use of transducer for a particular application. This theory course is well complemented by a laboratory course under the name Transducer Engineering Lab in the same semester that helps a student learn with hands-on experience.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1
Test-2	25 Marks	Based on Unit-2 & Unit-3 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-4 to Unit-5 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	100 Marks	

Learning Resources:

Tutorials and lecture slides will be assigned to the student: Digital copy will be available on the JUET server.

Text Books:

[1] A.K.Sawhney & Puneet Sawhney, A Course in Mechanical Measurements and Instrumentation, 12/e, Dhanpat Rai & Co. (P) Ltd.,2004

[2] B.C.Nakra & K.K.Chaudhary,Instrumentation Measurement And Analysis, Tata McGraw-Hill Publishing Company Ltd, New Delhi.,1996

[3] D.Patranabis, Principles of Industrial Instrumentation, 2/e, Tata McGraw-Hill Publishing Company Ltd, New Delhi.,1998

Reference Books/Materials:

[1] James W. Dally, William F. Riley & Kenneth G.McConnell, Instrumentation for Engineering Measurements,2/e,Wiley Student Edition, John Wiley & Sons,INC,2003.

[2] John P.Bentley, Principles of Measurement Systems, Low Price Edition, Pearson Education Asia,2000

[3] Dr.D.S.Kumar, Mechanical Measurements and Control, 3/e, Reprint-2004, Metropolitan Book Co. Private Ltd.,2004

[4] Liptak, B.G., "Instrumentation Engineers Handbook (Measurement)", CRC Press, 2005.

Web References:

[1] https://nptel.ac.in/courses/108/108/108108147/

[2] https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/112104250/lec21.pdf

[3] https://www.electronics-tutorials.ws/io/io_1.html

Journals References:

[1] Sensors and Actuators A: Physical (Elsevier)

[2] Journal of Sensors (Hindawi)

Title: Transducer Engineering Laboratory **Code:**

L-T-P scheme: 0-0-2 **Credit: 1**

Objectives:

1. To understand the principle of operation and the important characteristics of transducers commonly used in industry.
2. To familiarize with the selection criterion and installation process of transducers.
3. To design the appropriate signal conditioning circuit for specific measurement requirement.

Learning Outcomes: In reference to Transducer Engineering (18B11EC914), the students will be able to:

Course Outcome	Description
CO1	Outline various types of transducers used in the automation industry.
CO2	Describe the constructional details and working of various types of the transducer.
CO3	Develop a signal conditioning circuit to interface the transducer to the digital systems.
CO4	Identify and select a transducer for a specific measurement requirement.
CO5	Apply the analytical techniques to evaluate the performance of the transducer.
CO6	Demonstrate the application of various transducers.

Course Content:

Unit I: Lab exercise based on introduction to sensors and transducers

Unit II: Lab exercise based on working of various transducers

Unit III: Lab exercise based on implementation of interfacing circuits to convert non-electrical signals to electrical signals.

Unit IV: Lab exercise based on measurement of physical parameters such as temperature, force, flow-rate etc.

Unit V: Lab exercise based on the determination of electrical properties such as resistance, inductance, capacitance

Teaching Methodology:

This course is introduced to help the students to familiarize with the devices and methods used for automatic measurement. In this course, the mixed technique of interactive discussion, regular assignments will be used. In the discussion the fundamental theoretical concepts will be introduced and demonstrated through examples. Discussion will be implemented in laboratory by using the practical setups.

Evaluation Scheme:

Exams		Marks	Coverage
P-1		15 Marks	Based on Lab Exercises: 1-5
P-2		15 Marks	Based on Lab Exercises: 6-11
Day-to-Day Work	Viva	20 Marks	70 Marks
	Demonstration	20 Marks	
	Lab Record	15 Marks	
	Attendance & Discipline	15 Marks	
Total		**100 Marks**	

Learning Resources:

Study material of Measurement & Instrumentation Lab (will be added from time to time): Digital copy will be available on the JUET server.

Text Books:

[1] A.K.Sawhney & Puneet Sawhney, A Course in Mechanical Measurements and Instrumentation, 12/e, Dhanpat Rai & Co. (P) Ltd.,2004

[2] B.C.Nakra & K.K.Chaudhary,Instrumentation Measurement And Analysis, Tata McGraw-Hill Publishing Company Ltd, New Delhi.,1996

[3] D.Patranabis, Principles of Industrial Instrumentation, 2/e, Tata McGraw-Hill Publishing Company Ltd, New Delhi.,1998

Reference Books/Materials:

[1] James W. Dally, William F. Riley & Kenneth G.McConnell, Instrumentation for Engineering Measurements,2/e,Wiley Student Edition, John Wiley & Sons,INC,2003.

[2] John P.Bentley, Principles of Measurement Systems, Low Price Edition, Pearson Education Asia,2000

[3] Dr.D.S.Kumar, Mechanical Measurements and Control, 3/e, Reprint-2004, Metropolitan Book Co. Private Ltd.,2004

[4] Liptak, B.G., “Instrumentation Engineers Handbook (Measurement)”, CRC Press, 2005.

Web References:

[1]https://nptel.ac.in/courses/108/108/108108147/

[2] https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/112104250/lec21.pdf

[3] https://www.electronics-tutorials.ws/io/io_1.html

Journals References:

[1] Sensors and Actuators A: Physical (Elsevier)

[2] Journal of Sensors (Hindawi)

Title: Digital Control System *Code:*

L-T-P Scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied courses, "*Control Systems*".

Objective:

1. To familiarize the student with the working of automation systems.
2. To develop an ability to design a computer-aided control system with given requirements.

Learning Outcomes:

Course Outcome	Description
CO1	Outline various digital control systems and their application.
CO2	Describe the element and operation of a digital control system.
CO3	Develop the architecture of an automation system based on the specified requirements.
CO4	Identify the hardware and software components of a computer-aided control system.
CO5	Application of digital control systems on a given assignment/ project.
CO6	Demonstration and deployment of basic software modules of a digital control system.

Course Content:

Unit I: Introduction to Digital Control: Review of conventional control system. Manual and automatic control schemes. Model-based and model-less control. Need of automatic control, Advantages, Limitations, and Applications.

Unit II: Programmable Logic Controller: History of programmable logic controller (PLC). Architecture of PLC, Elements of PLC, CPU, IO Modules, Power supply and Communication Modules, Input Output Devices, Interfacing of Field Devices.

Unit III: Distributed Control Systems: Basics of Distributed Control Systems (DCS). Architecture and Working, Components of DCS, Field Instruments and Interfacing Circuits, Communication Protocols, Control of Field Instruments using Relay Devices.

Unit 4: Supervisory Control and Data Acquisition (SCADA): Introduction to SCADA. Fundamental Principle of Modern SCADA Systems, SCADA Hardware and Software, Remote Terminal Units (RTU). Master Station, Interfacing between SCADA and PLC.

Unit 5: Design of Industrial Automation Setup: Requirement gathering, System layout, Identification of Modules, Hardware Implementation, Software design, Case Study of Industrial Automation in Food Processing and Manufacturing Industry.

Teaching Methodology:

This course is introduced to help students transition from a simple electrical and electronics engineering concepts to applications of digital control system. Starting with the understanding of continuous systems, the student will be able to understand computer-aided control and other aspects of system analysis. The entire course is broken down into five separate units to develop an understanding of various aspects of automation. Each section includes multiple technologies to help a student gain more experience as an electronic control system designer.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1, Unit-2
Test-2	25 Marks	Based on Unit-3 & Unit-4 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-5 to Unit-6 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Lecture notes/slides on Digital Control System (will be added from time to time): Digital copy will be available on the JUET server.

Text Books:

[1] K.S. Manoj, Industrial Automation with SCADA: Concepts, Communications and Security, Notion Press, 1/e, Indian Edition, 2019.

[2] T.R. Kurfess, Robotics and Automation Handbook, CRC Press, 2/e, Indian Edition, 2004.

Reference Books/Material:

[1] G. F. Franklin, J. D.Powell and M. L. Workman, Digital Control of Dynamic Systems, Addison Wesley, 1998,Pearson Education,Asia, 3/e, 2000.

[2] K. J.Astroms and B. Wittenmark, Computer Controlled Systems - Theory and Design, Prentice Hall, 3/e, 1997.

Web References:

[1] https://nptel.ac.in/courses/108/105/108105088/

[2] https://www.eolss.net/

Journals References:

[1] Science direct journal of digital control system

[2] IRE Transactions on Industrial Electronics

Title: Microcontroller & Embedded System **Code:**

L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied courses, "*Microprocessor & Interfacing*".

Objective:

1. To understand the basic principles of microcontroller and embedded systems
2. To implement various project based on different interfacing with microcontroller

Learning Outcomes:

Course Outcome	Description
CO1	Realize of the fundamentals of a microprocessor
CO2	Understand the architecture of microcontroller 8051
CO3	Be trained in the instruction set and microcontroller programming
CO4	Express the memory and input/output interfacing with controllers
CO5	Foster ability to understand the role of embedded systems in industry
CO6	Design and analyze real time embedded systems using the concepts of processor

Course Content:

Unit-I: Fundamentals of Microprocessors: Fundamentals of microprocessor architecture. 8-bit microprocessor and microcontroller, architecture, comparison of 8-bit microcontrollers, 16-bit and 32-bit microcontrollers. Embedded system and its characteristics, Role of microcontrollers in embedded Systems. Overview of the 8051 family.

Unit-II: 8051 Architecture: Internal Block Diagram, CPU, ALU, address, data and control bus, working registers, special function register, Clock and Reset circuits, Stack and Stack Pointer, Program Counter, I/O ports, Memory Structures, Data and Program Memory, Timing diagrams and Execution Cycles.

Unit-III: Instruction Set and Programming: Addressing modes: Introduction, Instruction syntax, Data types, Subroutines Immediate addressing, Register addressing, Direct addressing, Indirect addressing, Relative addressing, Indexed addressing, Bit inherent addressing, bit direct addressing. 8051 Instruction set, Instruction timings. Data transfer instructions, Arithmetic instructions, Logical instructions, Branch instructions, Subroutine instructions, Bit manipulation instruction. Assembly language programs, C language programs. Assemblers and compilers. Programming and debugging tools.

Unit-IV: Memory and I/O Interfacing: Memory and I/O expansion buses, control signals, memory wait states. Interfacing of peripheral devices such as General Purpose I/O, ADC, DAC, timers, counters and memory devices.

Unit-V: External Communication Interface: Synchronous and Asynchronous Communication. RS232, SPI, I2C. Introduction and interfacing to protocols like Blue-tooth and Zig-bee.

Unit-VI: Applications: LED, LCD and keyboard interfacing,Stepper motor interfacing, DC Motor interfaces and sensor interfacing.

Unit-VII: Embedded System: concept of embedded systems design, embedded microcontroller cores and memories, examples, technological aspects of embedded systems: interfacing between analog and digital blocks, signal conditioning, digital signal processing. Subsystem interfacing, interfacing with external systems, user interfacing, design tradeoffs due to process compatibility, thermal considerations, etc., software aspects of embedded systems: real time programming languages and operating systems for embedded systems.

Teaching Methodology:

This course is introduced to help students for understanding the basic concept of microcontroller. Initially an overview of microprocessor is discussed briefly. In the first part, 8051 microcontroller is elaborated with the help of architecture followed by assembly language programming. In the second part, various types of interfacing such as memory, Input output and external interface etc is implemented with 8051 microcontroller. Afterward, application of microcontroller is explained by suitable examples. At the end, embedded system is described in details. Moreover, hardware and software aspects of embedded system has been elaborated with appropriate model and example.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15	Based on Unit-1, Unit-2 & Unit-3
Test-2	25	Based on Unit-4 & Unit-5 and around 30% from coverage of Test-1
Test-3	35	Based on Unit-6 to Unit-7 and around 30% from coverage of Test-2
Assignment	10	Based on Unit-1, Unit-4 & Unit-6
Tutorials	5	Based on Unit-2 & Unit-5
Quiz	5	Based on Unit-3 & Unit-7
Attendance	5	Based on attendance in the theory classes
Total	**100**	

Learning Resources:

Lecture slides on theory course will be added from time to time and a digital copy of study material will be available on the JUET server.

Text Book:

[1] "The 8051 microcontroller" K. J. Ayala, Cengage Learning, 2005

[2] "8051 Microcontroller and embedded systems using assembly and C", M. A. Mazidi, J. G. Mazidi and R. D. Mckinlay, 2nd edi.,

Reference Books:

[1] "*Embedded system*", R. Kamal., 2nd edi., Tata McGraw Hill, 2008.

[2] "*Embedded micro computer systems*: *Real time interfacing*", Thomson learning 2001.

Web References:

[1] https://www.tutorialspoint.com/microprocessor/microcontrollers_8051_architecture

[2] https://www.codrey.com/embedded-systems/

Journals References:

[1] International Journal of Embedded Systems inder science publication

[2] Journal of Microcontroller Engineering and Applications

Title: Embedded Control System **Code:**

L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have previous knowledge of introduction to microprocessor and controllers and embedded control system.

Objective:

1. To explain the various concepts used in embedded control systems.

Learning Outcomes:

Course Outcome	Description
CO1	Express the introduction of embedded systems and microcontroller
CO2	Identify with the concept of analog-to-digital conversion system
CO3	Understand the concept Input /Output Interfacing of embedded system
CO4	Develop programming and tools using hardware and software
CO5	Analyze the need of Real time Operating System (RTOS) in embedded systems
CO6	Work as a team on a project.

Course Content:

Unit-1: Introduction: Introduction to Embedded Systems, Its Architecture and system Model, Introduction to the HCS12/S12Xseries Microcontrollers, Embedded Hardware Building Block.

Unit-2: HCS12 System Description and Programming: The HCS12 Hardware System ,Modes of Operation, The B32 Memory System , The HCS12 DP256 Memory System, Exception Processing–Resets and Interrupts, Clock Functions, TIM, RTI, Serial Communications, SPI-Serial Peripheral Interface, I2C, HCS12 Analog-to-Digital Conversion System.

Unit-3: Basic Input /Output Interfacing Concepts: Input Devices, Output Devices and their Programming, Switch Debouncing, Interfacing to Motor, LCDs, Transducer, The RS-232 Interface and their Examples.

Unit-4: Development tools and Programming: Hardware and Software development tools, C language programming, Codewarior tools- Project IDE, Compiler, Assembler and Debugger, JTAG and Hardware Debuggers, Interfacing Real Time Clock and Temperature Sensors with I2C and SPI bus.

Unit-5:Real-time Operating Systems (RTOS): Basic concepts of RTOS and its types, Concurrency, Reentrancy, Inter task communication, Implementation of RTOS with some case studies.

Teaching Methodology:

This course is introduced to help students transition from a simple the concept of embedded Systems and its architecture and real-time operating systems.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1, Unit-2
Test-2	25 Marks	Based on Unit-3 & Unit-4 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-5 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and lecture slides on Embedded Control System (will be added from time to time): Digital copy will be available on the JUET server.

Text Books:

[1] Barrett, S.F. and Pack, J.D., Embedded Systems, Pearson Education (2008).

[2] Haung, H.W., The HCS12 / 9S12: An Introduction to Software and Hardware Interfacing, Delmar Learning (2007).

Reference Books:

[1]Fredrick, M.C., Assembly and C programming for HCS12 Microcontrollers, Oxford University Press (2005).

[2]Ray, A.K., Advance Microprocessors and Peripherals-Architecture, Programming and Interfacing, Tata McGraw-Hill (2007).

Web References:

[1] www.embedded.com

[2] web.eecs.umich.edu

Journals References:

[1] Journal of Advanced Research in Embedded System

[2] American Journal of Embedded Systems and Applications

[3] Embedded Control System for Smart Walking Assistance

Title: Real Time Embedded Systems design **Code:**

L-T-P scheme: 3- 0 -0 **Credit: 3**

Prerequisite: Students must have the concept of "*Digital Electronics"* and "*Microprocessor Interfacing*".

Objective:

The objective of this course is to familiarize students with the issues and technologies involved in designing real-time and hardware-resource constrained systems. Design engineers are often called upon to make decisions about general purpose computing solutions vs. specialized hardware solutions,

Learning Outcomes:

Course Outcome	Description
CO1	Understand the vision and design of embedded systems with respect to the requirements of today's scenario used in technical industries fulfilling the user requirement.
CO2	Understanding the subject knowledge of basics on Embedded systems, Real time systems, Embedded system design and model, Standards and Networking.
CO3	Able to understand the design of embedded processors and types, parallelism, Memory Architecture, Hierarchy, Models, Input and Output hardware, The analog and digital interface.
CO4	Able to design real-time system with its multitasking and scheduling nature.
CO5	Able to analyze the Reachability and checking various models.
CO6	Able to have the knowledge of different analysis method and Fault tolerance techniques in real time systems.

Course Content:

Unit -I: Introduction: Definition of embedded system, Real Time Systems, Hardware Architecture, Embedded system design and model, Standards and Networking.

Unit-II: Design of Embedded Systems: Embedded processors and types, parallelism, Memory Architecture, Hierarchy, Models, Input and Output hardware, The analog and digital interface .

Unit-III: Real time multitasking and scheduling: Imperative Programs, Threads, process and message passing, Scheduling, Rate monotonic scheduling, Earliest deadline first, Scheduling and mutual exclusion, Multiprocessor scheduling.

Unit-IV: Analysis and Verification: Invariant and temporal logics, Linear temporal logic, models as specification, Type equivalence and refinement, language equivalence and containment.

Unit-V: Reach ability Analysis and Model checking: Open and Closed Systems, Reachability Analysis, Abstraction in Model Checking, Model Checking Liveness Properties.

Unit-VI: Quantitative Analysis: Extreme-Case Analysis, Threshold Analysis, Average-Case Analysis, Basics of Execution Time Analysis, Optimization Formulation, Logical Flow Constraints, Bounds for Basic Blocks.

Teaching Methodology:

This course will give students the tools to intelligently make the necessary tradeoffs and understand the business consequences of their choices after the successful completion of this course. Lectures would be more theoretical and it would cover the core concepts that are explained in the text and reference materials with adequate examples.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1and Unit-2
Test-2	25 Marks	Based on Unit-3 & Unit-4 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-5 to Unit-6 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and lecture slides on Web Development (will be added from time to time): Digital copy will be available on the JUET server.

Text Books:

[1] Tammy Norgaard, "Embedded Systems Architecture," Newes, 2005, ISBN 0-7506-7792-9.

[2] Edward A. Lee and Sanjit A. Seshia, "Introduction to Embedded Systems, A Cyber-Physical Systems Approach", http://LeeSeshia.org, ISBN 978-0-557-70857-4, 2011.

Reference Books:

[1] Giorgio C. Buttazzo, Hard Real-Time Computing Systems, Springer, 2004.

Web References:

[1] https://nptel.ac.in/courses/108/105/108105057/

[2]https://nptel.ac.in/courses/106105036/

[3] https://nptel.ac.in/courses/108102045/

[4] https://www.allaboutcircuits.com/technical-articles/introduction-to-real-time-embedded-systems/

Journals References:

[1]EURASIP Journal on Embedded Systems

[2]Embedded System and Intelligent Control by Hindawi

[3]IEEE Embedded system security

Title: Measurement & Instrumentation **Code: EC109**
L-T Scheme: 3-0-0 **Credits: 3**
Prerequisite: Nil
Objectives:

1. To introduce students to the automatic measurement process.
2. To understand students how different types of meters work and their construction.
3. To provide a student knowledge of the various types of sensors and their signal conditioning circuits.
4. To develop the ability to use modern tools necessary for hardware projects.

Course Outcomes:

Course Outcome	Description	Bloom's Level
CO1	Summarize various characteristics of transducers and instrument and their needs in the industry	BL2
CO2	Examine the behaviour of signal conditioning circuits in the field of measurement and instrumentation	BL4
CO3	Illustrate working of CRO and techniques to analyse various waveforms with related parameters suing CRO	BL2
CO4	Analyse the errors in measurements using linear & non linear instruments	BL4

Course Content:

Unit I: Fundamentals of Measurement: Measurement Methods, Generalized measurement System, Classification of Instruments, Static & Dynamic Characteristics, Errors & Uncertainty measurement of system, Linear & Non-linear Systems.

Unit II: Transducers: Transducers – Classification of transducers, Temperature transducer, Pressure transducer, Displacement transducer, Strain gauge, LVDT, RTD, Thermistor, Thermocouple, Peizo-electric transducer.

Unit III: Signal Conditioning Circuits: D.C. bridges and their application in measurement of resistance, Kelvin's double bridge, A.C. Bridges- general equation, Potentiometer- DC potentiometer, Multi-range potentiometer, Q-meter and its applications. Amplifiers, Attenuators, Filters, Instrumentation Amplifier, Analog to digital converts.

Unit IV: Electrical Instruments: Moving coil, Moving iron, PMMC, Dynamometer and Induction type instruments, Measurement of Voltage, Current, Power, Power Factor, Energy, Instrument Transformer - current and potential transformer, Measurement of Phase & Frequency.

Unit V: Signal Generators and Display Devices: Multivibrators: astable, mono-stable and bi-stable types. Generation of square and triangular waveforms, IC 555 timer and its application in multivibrators. Construction & working of Basic CRO, its Components (Deflection plates, Screen, Aquadag, Time Base Generator, Oscilloscope Amplifiers), Measurements of phase and frequency (Lissajous Patterns), Types of CRO, Special types of CRO, Types of CRO Probes, Digital Voltmeter.

Teaching Methodology:

This course is introduced to familiarize the student with the devices and processes utilized in the automation industry. Starting from the basic concepts, the student will gradually develop an

understanding of practical setups used in the industry. The entire course is broken down into five units, such that each unit covers a particular aspect of the measurement process. This theory course is well complemented by a laboratory course under the name Measurement and Instrumentation Lab in the same semester that helps a student learn with hands-on experience.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1, Unit-2
Test-2	25 Marks	Based on Unit-2 & Unit-3 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-4 to Unit-5 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and lecture slides on Measurement & Instrumentation (will be added from time to time): Digital copy will be available on the JUET server.

Text Books:

[4] A.K.Sawhney & Puneet Sawhney, A Course in Mechanical Measurements and Instrumentation, 12/e, Dhanpat Rai & Co. (P) Ltd.,2004

[5] Albert D.Helfrick & William D.Cooper, "Modern Electronic Instrumentation and Measurement Technique",Low Price Edition, Pearson Education, 2005

[6] Ernest O.Doebelin, "Measurement Systems Application and Design", 5/e, Tata McGraw –Hill Publishing Company Ltd., 2004

Reference Books/Materials:

[5] H.S.Kalsi, "Electronic Instrumentation", Technical Education Series, Tata McGraw –Hill Publishing Company Ltd.,2001

[6] D.C. Kulshreshtha, "Principles of Electrical Engineering", Tata McGraw Hill Publishing Co

Web References:

[4] https://nptel.ac.in/courses/108105153/

[5] https://nptel.ac.in/courses/108/105/108105064/

Journals References:

[3] International Journal of Instrumentation Technology (Inderscience)

[4] IEEE Transactions on Instrumentation and Measurement

Title: Digital Control System **Code:**

L-T-P Scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied courses, "*Control Systems*".

Objective:

3. To familiarize the student with the working of automation systems.
4. To develop an ability to design a computer-aided control system with given requirements.

Learning Outcomes:

Course Outcome	Description
CO1	Outline various digital control systems and their application.
CO2	Describe the element and operation of a digital control system.
CO3	Develop the architecture of an automation system based on the specified requirements.
CO4	Identify the hardware and software components of a computer-aided control system.
CO5	Application of digital control systems on a given assignment/ project.
CO6	Demonstration and deployment of basic software modules of a digital control system.

Course Content:

Unit 1: Introduction to Digital Control: Review of conventional control system. Manual and automatic control schemes. Model-based and model-less control. Need of automatic control, Advantages, Limitations, Applications.

Unit 2: Programmable Logic Controller: History of programmable logic controller (PLC). Architecture of PLC. Elements of PLC, CPU, IO Modules, Power supply and Communication Modules, Input Output Devices, Interfacing of Field Devices.

Unit 3: Distributed Control Systems: Basics of Distributed Control Systems (DCS). Architecture and Working. Components of DCS, Field Instruments and Interfacing Circuits, Communication Protocols. Control of Field Instruments using Relay Devices.

Unit 4: Supervisory Control and Data Acquisition (SCADA): Introduction to SCADA. Fundamental Principle of Modern SCADA Systems. SCADA Hardware and Software. Remote Terminal Units (RTU). Master Station. Interfacing between SCADA and PLC.

Unit 5: Design of Industrial Automation Setup: Requirement gathering, System layout, Identification of Modules, Hardware Implementation, Software design. Case Study of Industrial Automation in Food Processing and Manufacturing Industry.

Teaching Methodology:

This course is introduced to help students transition from a simple electrical and electronics engineering concepts to applications of digital control system. Starting with the understanding of continuous systems, the student will be able to understand computer-aided control and other aspects of system analysis. The entire course is broken down into five separate units to develop an understanding of various aspects of automation. Each section includes multiple technologies to help a student gain more experience as an electronic control system designer.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1, Unit-2
Test-2	25 Marks	Based on Unit-3 & Unit-4 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-5 to Unit-6 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Lecture notes/slides on Digital Control System (will be added from time to time): Digital copy will be available on the JUET server.

Text Books:

[3] K.S. Manoj, Industrial Automation with SCADA: Concepts, Communications and Security, Notion Press, 1/e, Indian Edition, 2019.

[4] T.R. Kurfess, Robotics and Automation Handbook, CRC Press, 2/e, Indian Edition, 2004.

Reference Books/Material:

[3] G. F. Franklin, J. D.Powell and M. L. Workman, Digital Control of Dynamic Systems, Addison Wesley, 1998,Pearson Education,Asia, 3/e, 2000.

[4] K. J.Astroms and B. Wittenmark, Computer Controlled Systems - Theory and Design, Prentice Hall, 3/e, 1997.

Web References:

[3] https://nptel.ac.in/courses/108/105/108105088/

[4] https://www.eolss.net/

Journals References:

[3] Science direct journal of digital control system

Title: Sensors, Actuators & Signal Processing **Code:**

L-T-P Scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied course, "*Instrumentation and control*".

Objective:

The aim is to provide knowledge of sensor technology, features and characteristics of sensors, measuring devices and sensor and actuators applications in industry.

Learning Outcomes:

Course Outcome	Description
CO1	Outline the basics of sensors, Principles, Classification, Parameters, Basic requirements of sensors.
CO2	Describe the types of electrical and electronic sensors.
CO3	Develop the appropriate technology to implement digital sensors.
CO4	Identify Concepts of Actuators, Types of actuators, Actuator performance criteria and selection.
CO5	Applications of naming, addressing, time synchronization and routing protocols.
CO6	Demonstrate deployment and basic maintenance skills.

Course Content:

Unit-I: Fundamentals of sensors :Introduction to sensors , Principles, Classification, Parameters, Basic requirements of a sensors- Classification of sensors- Static and dynamic characteristics of sensors..

Unit-II: Electrical and Electronic sensors: Overview of analog mechanical, pneumatic and hydraulic, optical and opto-electronic sensors, electric and electronic sensors, Capacitive and Inductive type displacement sensor- position sensors, Resistive sensors, strain sensors, photoelectric sensors, fiber optic sensors and piezoelectric sensors.

Unit-III: Digital Sensors: Digital sensors, incremental sensors, position converters. Sensors to detect the position - Hall sensors, Sensors for measuring humidity and analyze the gases and the environment. Reflective optical and ultrasonic range finders. Sensors to measure speed and acceleration.

Unit-IV: Actuators: Basic Concepts of Actuators, Types of actuators, Actuator performance criteria and selection, Fluidic actuators, Solenoids and voice coil motors, Stepper motors, DC motors, Piezo-electric actuators, Shape memory alloy actuators.

Unit-V: Signal Processing: Introduction, Fourier series and Fourier Transform representation of continuous and discrete time signals, Amplification, Filters, Converters, Compensation.

Teaching Methodology:

This course is introduced to help students to learn about various sensors, actuators and their functions. At the end of the course the student will be able to analyze, design, and evaluate digital circuits, of medium complexity, that are based on SSIs, MSIs, and programmable logic devices.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1 & Unit-2.
Test-2	25 Marks	Based on Unit-2 & Unit-3 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-4 to Unit-5 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and lecture slides on Sensors, Actuators and Signal Processing (will be added from time to time): Digital copy will be available on the JUET server.

Text Books:

[1] D. Patranabis, “Sensors and Transducers”, PHI Learning Private Limited.
[2] Patranabis, “Sensors and Actuators”, 2nd Edition, PHI, 2013.

Reference Books:

[1] Julian W.Gardner and Vijay K Varadhan, “Microsensors, MEMS and Smart Devices”, John Wiley & sons, 2001.

Web References:

[1] Tiny Battery May Power Next-Gen Gadgets. Arthur Tham. News Digest. 24-Feb-2003.http://www.extremetech.com/article2/0,3973,901021,00.asp
[2] “Carbon-MEMS Architectures for 3D Micro-batteries” PowerPoint Presentation. Marc Madou. Department of Mechanical and Aerospace Engineering. UCI, October 14, 2003.

[3] “MEMS for Environmental and Bioterrorism Applications”. Southwestern Center for Microsystem Education and BioLink, 2009.

Journal References:

[1] IEEE Journal on Sensors
[2] IEEE Transactions on Vehicular Technology

Title: Robotics & Machine Vision **Code:**
L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite

Students must have the concept of Microprocessors and Microcontrollers.

Objective:

1. To familiarize students with the concepts and techniques of robot manipulator, its kinematics,
2. Programming and build confidence to evaluate choose and incorporate robots in engineering systems.

Learning Outcomes:

Course Outcome	Description
CO1	Explain the basic concepts like various configurations, classification and parts of robots.
CO2	To get the basic knowledge regarding the concepts of kinematics, degeneracy, dexterity and trajectory planning.
CO3	Compare various end effectors (grippers and tools) and sensors used in robots.
CO4	Analyze the concept of Artificial Intelligence in robots.
CO5	Understanding various types of robot programming and its applications.
	To educate on various path planning techniques and understanding various types of robot programming and its applications.
CO6	To analyze Instrumentation systems and their applications to various robotic systems with the introduction of the manipulator differential motion and control. Also demonstrate the image processing and image analysis techniques by machine vision system.

Course Content:

Unit-I: Fundamentals of Robot: Robotics – Introduction – Basic structure – Classification of robot and Robotic systems – laws of robotics – work space, precision movement. Drives and Controls systems: Hydraulic systems, power supply – servo valve – hydraulic motor – DC servo motors – stepper motors – operation – selection of system – control system – servo control.

Unit-II: Robot Motion Analysis: Kinematics of Robot: Introduction, Matrix Representation, homogeneous transformation, forward and inverse kinematics, Inverse kinematics Programming, Degeneracy, dexterity, velocity and static forces, Basics of trajectory planning.

Unit-III: Grippers and Sensors: Robot end effectors: Types of end effectors – Mechanical grippers – Types of Gripper mechanisms – Grippers force analysis – Other types of grippers – Vacuum cups – Magnetic grippers – Adhesive grippers – Robot end effectors interface. Sensors: Position sensors – Potentiometers, encoders, - LVDT, Velocity sensors, Acceleration Sensors, Force, Pressure and Torque sensors, Touch and Tactile sensors, Proximity, Range and sniff sensors.

Unit-IV: Programming and Application: Types of programming – programming languages sample program for different types of robots – Industrial Applications: Application of robots in processing operations – Assembly and inspections – Material handling – Loading and unloading – AI and Robotics.

Unit-V: Machine Vision: Introduction – image processing vs image analysis, image acquisition, digital images – sampling and quantization – image definition, levels of computation. Image processing Techniques: Data reduction – Windowing, digital conversion. Segmentation – Thresholding, Connectivity, Noise reduction, Edge detection, Segmentation, Region growing and Region splitting, Binary morphology and grey morphology operation – feature extraction.

Teaching Methodology:

The students will be able to explain the basic concepts like various configurations, classification and parts of robots. He would also be able to explain the concept of kinematics, degeneracy, dexterity and trajectory planning, compare various end effectors (grippers and tools) and sensors used in robots, analyze the concept of Artificial Intelligence in robots, various types of robot programming and its applications, demonstrate the image processing and image analysis techniques by machine vision system. Lectures would be interactive and it would cover the core concepts that are explained in the text and reference materials with adequate examples.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1, Unit-2(30%)
Test-2	25 Marks	Based on Unit-2(70%) & Unit-3 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-4 to Unit-5 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and lecture slides on Web Development (will be added from time to time): Digital copy will be available on the JUET server.

Text Books

[1] Saeed B.Niku, Introduction to Robotics: Analysis, Systems, Applications, 2nd edition, Pearson Education India, PHI 2003 (ISBN 81-7808-677-8)

[2] M.P.Groover, Industrial Robotics – Technology, Programming and Applications, McGraw- Hill, USA, 1986

Reference Books

[1] Janakiraman P.A., Robotics and image processing, Tata McGraw Hill, 1995.

[2] YoremKoren, Robotics for Engineers, McGraw-Hill, USA, 1992.

[3] Richard D.Klafter, Thomas A.Chmielewski and Michael Negin, Robotic Engineering – An Integrated Approach, Prentice Hall Inc, Englewoods Cliffs, NJ, USA, 1989.

[4] Ramesh Jam, Rangachari Kasturi, Brain G.Schunck, Machine Vision, Tata McGraw Hill.

Web References:

[1] https://www.robotshop.com/community/blog/show/10-tips-for-getting-started-with-robotics

[2] https://nptel.ac.in/courses/112105236
[3]https://nptel.ac.in/courses/112/101/112101099/

Journals References:

[3] IEEE Journal on Robotics and Automation
[4] The International Journal of Robotics Research
[5] Robotics & artificial intelligence by springer
[6] Journal of Intelligent & Robotic Systems by springer

Title: Robotics Programming Lab **Code:**

L-T-P scheme: 3-0-0 **Credit: 3**

Prerequisite Students must have the concept of Microprocessors and Microcontrollers.

Objective:

1. To familiarize students with the concepts and techniques of robot manipulator, its kinematics,
2. Programming and build confidence to evaluate, choose and incorporate robots in engineering systems.

Learning Outcomes:

Course Outcome	Description
CO1	Outline based on the basic concepts like various configurations, classification and parts of robots.
CO2	To get the basic knowledge and compare the concepts of kinematics, degeneracy, dexterity and trajectory planning, various end effectors (grippers and tools) and sensors used in robots.
CO3	Analyze the concept of Artificial Intelligence in robots with its interfaces and basic coding understanding utilized in it.
CO4	Understanding various types of robot programming and its applications.
CO5	To analyze Instrumentation systems and their applications to various robotic systems with the introduction of the manipulator differential motion and control.
CO6	Demonstrate the image processing and image analysis techniques by machine vision system.

Course Content:

Unit -I: Fundamentals of Robot: Robotics – Introduction – Basic structure – Classification of robot and Robotic systems – laws of robotics – work space, precision movement. Drives and Controls systems: Hydraulic systems, power supply – servo valve – hydraulic motor – DC servo motors – stepper motors – operation – selection of system – control system – servo control.

Unit-II: Robot Motion Analysis: Kinematics of Robot: Introduction, Matrix Representation, homogeneous transformation, forward and inverse kinematics, Inverse kinematics Programming, Degeneracy, dexterity, velocity and static forces, Basics of trajectory planning.

Unit-III: Grippers and Sensors: Robot end effectors: Types of end effectors – Mechanical grippers – Types of Gripper mechanisms – Grippers force analysis – Other types of grippers – Vacuum cups – Magnetic grippers – Adhesive grippers – Robot end effectors interface. Sensors: Position sensors – Potentiometers, encoders, - LVDT, Velocity sensors, Acceleration Sensors, Force, Pressure and Torque sensors, Touch and Tactile sensors, Proximity, Range and sniff sensors.

Unit-IV: Programming and Application: Types of programming – programming languages sample program for different types of robots – Industrial Applications: Application of robots in processing operations – Assembly and inspections – Material handling – Loading and unloading – AI and Robotics.

Unit-V: Machine Vision: Introduction – image processing vs image analysis, image acquisition, digital images – sampling and quantization – image definition, levels of computation. Image

processing Techniques: Data reduction – Windowing, digital conversion. Segmentation – Thresholding, Connectivity, Noise reduction, Edge detection, Segmentation, Region growing and Region splitting, Binary morphology and grey morphology operation – feature extraction.

Teaching Methodology:

The students will be able to learn the basic concepts like various configurations, classification and parts of robots. He would also be able to see the concept of kinematics, degeneracy, dexterity and trajectory planning, compare various end effectors (grippers and tools) and sensors used in robots, analyze the concept of Artificial Intelligence in robots, various types of robot programming and its applications, demonstrate the image processing and image analysis techniques by machine vision system. In the discussion the fundamental theoretical concepts will be introduced and demonstrated through examples.

Evaluation Scheme:

Exams		**Marks**	**Coverage**
P-1		15 Marks	**Based on Lab Exercises: 1-5**
P-2		15 Marks	**Based on Lab Exercises: 5-10**
Day-to-Day Work	Viva	20 Marks	**70 Marks**
	Demonstration	20 Marks	
	Lab Record	15 Marks	
	Attendance & Discipline	15 Marks	
Total		**100 Marks**	

Learning Resources:

Study material of Robotics Programming Lab (will be added time to time): Digital copy will be available on the JUET server.

Text books

[1] Saeed B.Niku, Introduction to Robotics: Analysis, Systems, Applications, 2nd edition, Pearson Education India, PHI 2003 (ISBN 81-7808-677-8)

[2] M.P.Groover, Industrial Robotics – Technology, Programming and Applications, McGraw- Hill, USA, 1986

Reference books

[1] Janakiraman P.A., Robotics and image processing, Tata McGraw Hill, 1995.

[2] YoremKoren, Robotics for Engineers, McGraw-Hill, USA, 1992.

[3] Richard D.Klafter, Thomas A.Chmielewski and Michael Negin, Robotic Engineering – An Integrated Approach, Prentice Hall Inc, Englewoods Cliffs, NJ, USA, 1989.

[4] Ramesh Jam, Rangachari Kasturi, Brain G.Schunck, Machine Vision, Tata McGraw Hill.

Web References:

[1]https://www.robotshop.com/community/blog/show/10-tips-for-getting-started-with-robotics

[2] https://nptel.ac.in/courses/112105236

[3]https://nptel.ac.in/courses/112/101/112101099/

Journals References:

[1]IEEE Journal on Robotics and Automation

[2]The International Journal of Robotics Research

[3]Robotics & artificial intelligence by springer

[4]Journal of Intelligent & Robotic Systems by springer

Title: Internet of Things Technology Lab **Code:**

L-T-P Scheme: 0-0-2 **Credit: 1**

Prerequisite:

Students are expected to have a good understanding of computer networks, familiarity with network programming, and object oriented programming.

Objective:

The course is designed to give the students a solid grounding of the key technologies involved and how they are integrated to form complete Internet of Things(IoT) systems.

Learning Outcomes:

1. Understand how Arduino and raspberry work as IoT devices
2. Review the various network protocols & communication technology used in IoT.
3. Be familiar with data analytic with IoT

Course Outcomes:

Course Outcome	Description
CO1	Familiarization with different physical Device related to IoT
CO2	Understand the Arduino Programming
CO3	Work on LED and LCD
CO4	Understand various motor behavior
CO5	Illustrate the work function of various sensors

Course Content:

Lab Exercise: Arduino UNO, LED , LCD , Motion Sensor, Pressure sensor, Moisture sensor etc., Motors like as steeper, DC etc. Wifi, Bluetooth, Camera.

Teaching Methodology:

The students will be able to learn basic concepts of IoT programming.

Evaluation Scheme:

Internal Evaluation/ Exams	Marks	Coverage
P-1	15	Based on Lab Experiments: 1-6
P-2	15	Based on Lab Experiments: 7-12
Attendance & Discipline	15	Attendance (5) & Discipline (10)
Lab Record	15	Writing work
Day-to-Day Work	40	Viva-voce

Total	100	

Learning Resources:

Program on IoT will be added on the JUET server.

Text Books

1 Srinivasa K G, Siddesh G. M. & Hanumantha Raju R., "Internet of Things", 2nd Edition,Cenegae Education, 2019.

2 Shriram K Vasudevan, Abhishek S Nagarajan & RMD Sundram, "Internet of Things", 1st Edition,John Wiley & Sons,2019.

Title: Internet of Things Technology & Applications **Code:**

L-T-P Scheme: 2-0-0 **Credit: 2**

Prerequisite:

Students are expected to have a good understanding of computer networks, familiarity with network programming, and object oriented programming.

Objective:

The course is designed to give the students a solid grounding of the key technologies involved and how they are integrated to form complete Internet of Things(IoT) systems.

Learning Outcomes

1. Understand how Arduino and raspberry work as IoT devices
2. Review the various network protocols & communication technology used in IoT.
3. Be familiar with data analytic with IoT

Course Outcomes:

Course Outcome	Description
CO1	Familiarization with different physical Device related to IoT
CO2	Understand the IoT Architectures with devices
CO3	Demonstrate the various tools required in IoT
CO4	Review of various IoT protocols
CO5	Data analytic with IoT
CO6	Python programming for IoT

Course Content:

Unit I: IoT Physical Device & Endpoints: Arduino UNO, Raspberry Pi,Operating system, interfaces, Intel edison & Intel Galileo board, pcDuino,Beagle Black and Cubieboard

Unit II: IoT Architectures: Elements of IoT Architecture, Design considerations.

Unit III: IoT Application & Tools: Smart Perishable Tracking, lavatory Maintenance, Smart Warehouse, IoT possibility in retail sector, Smart driver assistance system etc., Chef, Setting up Chef, Pupet, Key concepts of Chef and Puppet.

Unit IV: IoT Protocols Message Queuing Telemetry Transport (MQTT), Constrained Application Protocol (CoAP), Bluetooth Low Energy(BLE), Light Fidelity (Li-Fi)

Unit V: Data analytic for IoT: Apache Hadoop, Map Reduce model, Hadoop YARN.Apache Oozie, Apache Spark.

Unit VI: IoT System using Python: Package, Amazon EC2, Auto-scaling, S3, RDS, Dynamo DB and Map reduce.

Teaching Methodology:

The students will be able to learn basic concepts of IoT, its working principle & operation of single layer and multilayer neural networks.

Evaluation Scheme:

Exams	**Marks**	**Coverage**
Test-1	15 Marks	Based on Unit-1, Unit-2
Test-2	25 Marks	Based on Unit- 3 & Unit-4 and around 20% from coverage of Test-1
Test-3	35 Marks	Based on Unit-5 and Unit-5 and around 20% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and lecture slides on IoT (will be added from time to time): Digital copy will be available on the JUET server

Text Books

1 Srinivasa K G ,Siddesh G. M. & Hanumantha Raju R., "Internet of Things", 2nd Edition,Cenegae Education, 2019.

2 Shriram K Vasudevan, Abhishek S Nagarajan & RMD Sundram, "Internet of Things", 1st Edition,John Wiley & Sons,2019.

3 Arshdeep Bahga & Vijay Madisetti, "Internet of Things-A Hands-on-Approach", 1st Edition, VPT, 2014.

Title: Transducers Engineering **Code:**

L-T Scheme: 3-0-0 **Credit: 3**

Prerequisite: Not Applicable

Objectives:

4. To understand the principle of operation and the important characteristics of transducers commonly used in industry.
5. To familiarize with the selection criterion and installation process of transducers.
6. To design the appropriate signal conditioning circuit for specific measurement requirement.

Learning Outcomes:

Course Outcome	Description
CO1	Outline various types of transducers concerning their application in the industry.
CO2	Describe the operating principle of various types of the transducer.
CO3	Develop skills to select a transducer for a specific measurement requirement.
CO4	Identify and use various transducers and signal conditioning circuits used in the measurement process.
CO5	Analyze the performance of the transducer.
CO6	Demonstrate the application of various transducers.

Course Content:

Unit I: Transducer Fundamentals: Basic concept of Sensors and transducer, their comparisons, Classification of Transducer, Working of transducers used for measurement of Displacement- resistive, inductive and capacitive method, Linear and Angular Velocity moving coil and moving magnet method, various tachometers and stroboscope, Acceleration- seismic and peizo electric accelerometer, Working principle of Capacitive Transducer, Piezo-Electric Transducer, and LVDT.

Unit II: Strain and Temperature Measurement: Measurement Strain Gauges- strain measurement technique, resistance strain gauge and its types, Signal conditioning of strain gauges, Transducers for Temperature Measurement- non- electrical and electrical method, Bimetallic Thermometer, Resistance Thermometer like RTD, Thermistor and Thermocouple, Radiation and Optical Pyrometer.

Unit III: Pressure Measurement: Transducers for Measurement of Pressure: - Manometers types (like Single column, inclined, U-tube), Mechanical Types (Bourdon, bellows and diaphragm), Elastic Types transducers, Low Pressure measurement gauges (Ionization, McLeod etc.).

Unit IV: Flow Measurement: Transducers for Measurement of Flow: - Types of flow meters, Theory of variable head constant area meter and its types, theory of constant head variable area meter and its types, theory of variable head variable area meter and its types, Special flow meters- Electromagnetic, Hot wire Anemometer, Turbine meter and Ultrasonic flow meter.

Unit V: Miscellaneous Measurement and Smart Sensor: Transducer for Level Measurement: - direct and indirect method, resistive method, Ultrasonic, Capacitive and Gamma Ray level Gauges, Measurement of Humidity and Moisture- basic definitions, psychometric method, Smart sensors - Fiber optic sensors, MEMS – Nano sensors, and proximity sensor.

Teaching Methodology:

This course is introduced to familiarize the student with the various transducers used in the automation industry. Starting from the basic concepts, the student will gradually develop an understanding of practical setups used in the industry. The entire course is broken down into five units, such that each unit covers the use of transducer for a particular application. This theory course is well complemented by a laboratory course under the name Transducer Engineering Lab in the same semester that helps a student learn with hands-on experience.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1
Test-2	25 Marks	Based on Unit-2 & Unit-3 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-4 to Unit-5 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	100 Marks	

Learning Resources:

Tutorials and lecture slides will be assigned to the student: Digital copy will be available on the JUET server.

Text Books:

[7] A.K.Sawhney & Puneet Sawhney, A Course in Mechanical Measurements and Instrumentation, 12/e, Dhanpat Rai & Co. (P) Ltd.,2004

[8] B.C.Nakra & K.K.Chaudhary,Instrumentation Measurement And Analysis, Tata McGraw-Hill Publishing Company Ltd, New Delhi.,1996

[9] D.Patranabis, Principles of Industrial Instrumentation, 2/e, Tata McGraw-Hill Publishing Company Ltd, New Delhi.,1998

Reference Books/Materials:

[7] James W. Dally, William F. Riley & Kenneth G.McConnell, Instrumentation for Engineering Measurements,2/e,Wiley Student Edition, John Wiley & Sons,INC,2003.

[8] John P.Bentley, Principles of Measurement Systems, Low Price Edition, Pearson Education Asia,2000

[9] Dr.D.S.Kumar, Mechanical Measurements and Control, 3/e, Reprint-2004, Metropolitan Book Co. Private Ltd.,2004

[10] Liptak, B.G., "Instrumentation Engineers Handbook (Measurement)", CRC Press, 2005.

Web References:

[6] https://nptel.ac.in/courses/108/108/108108147/

[7] https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/112104250/lec21.pdf

[8] https://www.electronics-tutorials.ws/io/io_1.html

Journals References:

[5] Sensors and Actuators A: Physical (Elsevier)

[6] Journal of Sensors (Hindawi)

Title: Transducer Engineering Laboratory **Code:**

L-T-P scheme: 0-0-2 **Credit: 1**

Objectives:

4. To understand the principle of operation and the important characteristics of transducers commonly used in industry.
5. To familiarize with the selection criterion and installation process of transducers.
6. To design the appropriate signal conditioning circuit for specific measurement requirement.

Learning Outcomes: In reference to Transducer Engineering (18B11EC914), the students will be able to:

Course Outcome	Description
CO1	Outline various types of transducers used in the automation industry.
CO2	Describe the constructional details and working of various types of the transducer.
CO3	Develop a signal conditioning circuit to interface the transducer to the digital systems.
CO4	Identify and select a transducer for a specific measurement requirement.
CO5	Apply the analytical techniques to evaluate the performance of the transducer.
CO6	Demonstrate the application of various transducers.

Course Content:

Unit I: Lab exercise based on introduction to sensors and transducers

Unit II: Lab exercise based on working of various transducers

Unit III: Lab exercise based on implementation of interfacing circuits to convert non-electrical signals to electrical signals.

Unit IV: Lab exercise based on measurement of physical parameters such as temperature, force, flow-rate etc.

Unit V: Lab exercise based on the determination of electrical properties such as resistance, inductance, capacitance

Teaching Methodology:

This course is introduced to help the students to familiarize with the devices and methods used for automatic measurement. In this course, the mixed technique of interactive discussion, regular assignments will be used. In the discussion the fundamental theoretical concepts will be introduced and demonstrated through examples. Discussion will be implemented in laboratory by using the practical setups.

Evaluation Scheme:

Exams		Marks	Coverage
P-1		15 Marks	Based on Lab Exercises: 1-5
P-2		15 Marks	Based on Lab Exercises: 6-11
Day-to-Day Work	Viva	20 Marks	70 Marks
	Demonstration	20 Marks	
	Lab Record	15 Marks	
	Attendance & Discipline	15 Marks	
Total		**100 Marks**	

Learning Resources:

Study material of Measurement & Instrumentation Lab (will be added from time to time): Digital copy will be available on the JUET server.

Text Books:

[4] A.K.Sawhney & Puneet Sawhney, A Course in Mechanical Measurements and Instrumentation, 12/e, Dhanpat Rai & Co. (P) Ltd.,2004

[5] B.C.Nakra & K.K.Chaudhary,Instrumentation Measurement And Analysis, Tata McGraw-Hill Publishing Company Ltd, New Delhi.,1996

[6] D.Patranabis, Principles of Industrial Instrumentation, 2/e, Tata McGraw-Hill Publishing Company Ltd, New Delhi.,1998

Reference Books/Materials:

[5] James W. Dally, William F. Riley & Kenneth G.McConnell, Instrumentation for Engineering Measurements,2/e,Wiley Student Edition, John Wiley & Sons,INC,2003.

[6] John P.Bentley, Principles of Measurement Systems, Low Price Edition, Pearson Education Asia,2000

[7] Dr.D.S.Kumar, Mechanical Measurements and Control, 3/e, Reprint-2004, Metropolitan Book Co. Private Ltd.,2004

[8] Liptak, B.G., “Instrumentation Engineers Handbook (Measurement)”, CRC Press, 2005.

Web References:

[4]https://nptel.ac.in/courses/108/108/108108147/

[5] https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/112104250/lec21.pdf

[6] https://www.electronics-tutorials.ws/io/io_1.html

Journals References:

[7] Sensors and Actuators A: Physical (Elsevier)

[8] Journal of Sensors (Hindawi)

Title: Robotics **Code:**
L-T-P Scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied courses, "*Engineering Mechanics, Engineering Drawing and Design and Theory of Machines*".

Objective:

1. To learn and know about the anatomy of robots and how to perform robots.
2. To develop the abilities to write a program for a typical application of robot.

Learning Outcomes:

Course Outcome	Description
CO1	Outline the terminology, components and subsystems of robots.
CO2	Describe the working principles of drive system, end effectors, sensor, and machine vision systems of robots.
CO3	Develop an idea to modify the motions or working of different joints and links in any robotic system.
CO4	Identify the most influencing parameters to fabricate the robotic system.
CO5	Apply appropriate technique to analyze the robot kinematics.
CO6	Demonstrate and deployment the skills to write the program for real world applications of robot.

Course Content:

Unit-I: Introduction: Past, Present & Future, Robot anatomy, Work volume, Applications, Components and Subsystems, Classification of robot.
Unit-II: Robot technology: robot and its peripherals- Basic control system concepts and model, controllers, End effectors, Different types of grippers and design concepts.
Unit-III: Robot Drives, Actuators and Control Drive systems: Hydraulic, Pneumatic and Electrical. DC motor, Stepper motor, Robot motion, and Path control, Controller.
Unit-IV: Robot Kinematics, Object location: Homogenous, Transformations.
Unit-V: Direct and Inverse kinematics, Dynamics of robots, Manipulator motion.
Unit-VI: Sensors and Perception- Types of sensors, Vision system, Computer Interfaces, Robot Programming.

Teaching Methodology:

This course is introduced for helping students how to tasks are performed by mechanical manipulators (Robots) in the industries. The entire course is broken down into six separate units: Robot terminology, Applications, Components and Subsystems, classification, grippers, actuators, controllers, Sensors, Kinematics and dynamics of robots, and robot programming.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1 and Unit-2
Test-2	25 Marks	Based on Unit-3 & Unit-4 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-5 and Unit-6 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	100 Marks	

Learning Resources:

Tutorials and lecture slides on Robotics Engineering (will be added from time to time): Digital copy will be available on the JUET server.

Text Book:

[1] "Robotics Technology and Flexible Automation", S. R. Deb, S. Tata McGraw Hill Education Pvt. Ltd, 2010.

[2] "Introduction to Robotics", John J. Craig, Pearson, 2009.

[3] "Industrial Robots - Technology, Programming and Applications", M. P. Groover, M. Weiss, R. N. Nagal, N.G. Odrey, A. Dutta, McGraw Hill, New York, 2008.

Reference Books/Material:

[1] "Robotics Engineering – An Integrated Approach", Richard D Klafter, Thomas A Chmielewski, Michael Negin, Eastern Economy Edition, Prentice Hall of India Pvt. Ltd., 2006.

[2] "Robotics : Control, Sensing, Vision and Intelligence", Fu K S, Gonzalez R C, Lee C.S.G, McGraw Hill, 198

Web References:

[1] https://nptel.ac.in/courses/112/105/112105249/

Title: Digital Control System **Code:**

L-T-P Scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied courses, "*Control Systems*".

Objective:

5. To familiarize the student with the working of automation systems.
6. To develop an ability to design a computer-aided control system with given requirements.

Learning Outcomes:

Course Outcome	Description
CO1	Outline various digital control systems and their application.
CO2	Describe the element and operation of a digital control system.
CO3	Develop the architecture of an automation system based on the specified requirements.
CO4	Identify the hardware and software components of a computer-aided control system.
CO5	Application of digital control systems on a given assignment/ project.
CO6	Demonstration and deployment of basic software modules of a digital control system.

Course Content:

Unit I: Introduction to Digital Control: Review of conventional control system. Manual and automatic control schemes. Model-based and model-less control. Need of automatic control, Advantages, Limitations, and Applications.

Unit II: Programmable Logic Controller: History of programmable logic controller (PLC). Architecture of PLC, Elements of PLC, CPU, IO Modules, Power supply and Communication Modules, Input Output Devices, Interfacing of Field Devices.

Unit III: Distributed Control Systems: Basics of Distributed Control Systems (DCS). Architecture and Working, Components of DCS, Field Instruments and Interfacing Circuits, Communication Protocols, Control of Field Instruments using Relay Devices.

Unit 4: Supervisory Control and Data Acquisition (SCADA): Introduction to SCADA. Fundamental Principle of Modern SCADA Systems, SCADA Hardware and Software, Remote Terminal Units (RTU). Master Station, Interfacing between SCADA and PLC.

Unit 5: Design of Industrial Automation Setup: Requirement gathering, System layout, Identification of Modules, Hardware Implementation, Software design, Case Study of Industrial Automation in Food Processing and Manufacturing Industry.

Teaching Methodology:

This course is introduced to help students transition from a simple electrical and electronics engineering concepts to applications of digital control system. Starting with the understanding of continuous systems, the student will be able to understand computer-aided control and other aspects of system analysis. The entire course is broken down into five separate units to develop an understanding of various aspects of automation. Each section includes multiple technologies to help a student gain more experience as an electronic control system designer.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1, Unit-2
Test-2	25 Marks	Based on Unit-3 & Unit-4 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-5 to Unit-6 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Lecture notes/slides on Digital Control System (will be added from time to time): Digital copy will be available on the JUET server.

Text Books:

[5] K.S. Manoj, Industrial Automation with SCADA: Concepts, Communications and Security, Notion Press, 1/e, Indian Edition, 2019.

[6] T.R. Kurfess, Robotics and Automation Handbook, CRC Press, 2/e, Indian Edition, 2004.

Reference Books/Material:

[5] G. F. Franklin, J. D.Powell and M. L. Workman, Digital Control of Dynamic Systems, Addison Wesley, 1998,Pearson Education,Asia, 3/e, 2000.

[6] K. J.Astroms and B. Wittenmark, Computer Controlled Systems - Theory and Design, Prentice Hall, 3/e, 1997.

Web References:

[5] https://nptel.ac.in/courses/108/105/108105088/

[6] https://www.eolss.net/

Journals References:

[4] Science direct journal of digital control system

[5] IRE Transactions on Industrial Electronics

Title: Computer-aided Control System/ Microprocessor Based Control System Code:
L-T-P Scheme: 3-0-0 Credit: 3
Prerequisite: Nil
Objective:

[1] To familiarize the student with the working of automation systems.
[2] To develop an understanding of a computer-aided control system and its design requirements.

Learning Outcomes:

Course Outcome	Description
CO1	Outline various digital systems used for control applications.
CO2	Describe the element and operation of a microprocessor.
CO3	Develop the architecture of an automation system based on the specified requirements.
CO4	Identify the hardware and software components of a computer-aided control system.
CO5	Application of industrial control systems on a given assignment/ project.

Course Content:

Unit I: Introduction to Digital Systems: Review of number system: Binary, Octal, Hexadecimal. Logic gates: AND, OR, NOT, Universal Gates. Digital signals and Circuits, Digital to Analog Converters, Analog to Digital Converters.

Unit II: Fundamentals of Microprocessors: Evolution of microprocessor, Word length, Hardware, Software, Input-Output Device, Single chip microcomputers. Semiconductor memory, RAM, ROM, EPROM. Architecture of Intel 8085 microprocessor: ALU, timing and control unit, registers, data and address bus, pin configuration. Instructions: op-code and operands. Interfacing with Memory and Input/Output Devices.

Unit III: Conventional Control System: Control system: working, applications. Open-Loop and Closed-Loop control. On/Off and Continuous Control, Manual and automatic control schemes. Model-based and model-less control. Need of automatic control, Advantages, Limitations, Applications.

Unit IV: Programmable Logic Controller: History of programmable logic controller (PLC). Architecture of PLC. Elements of PLC, CPU, IO Modules, Power supply and Communication Modules, Input Output Devices, Interfacing of Field Devices.

Unit V: Distributed Control Systems: Basics of Distributed Control Systems (DCS). Architecture and Working. Components of DCS, Field Instruments and Interfacing Circuits, Communication Protocols. Control of Field Instruments using Relay Devices.

Unit VI: Supervisory Control and Data Acquisition (SCADA): Introduction to SCADA. Fundamental Principle of Modern SCADA Systems. SCADA Hardware and Software. Remote Terminal Units (RTU). Master Station.

Teaching Methodology:

This course is introduced to help students to understand concepts of industrial control system. Starting with the understanding of continuous systems, the student will be able to understand computer-aided control and other aspects of system analysis. The entire course is broken down into six separate units to develop an understanding of various aspects of automation. Each

section includes multiple technologies to help a student gain more experience as an electronic control system designer.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1, Unit-2
Test-2	25 Marks	Based on Unit-3 & Unit-4 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-5 to Unit-6 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	100 Marks	

Learning Resources:

Lecture notes/slides on the course will be added from time to time. Digital copy will be available on the JUET server.

Text Books:

[1] K.S. Manoj, Industrial Automation with SCADA: Concepts, Communications and Security, Notion Press, 1/e, Indian Edition, 2019.

[2] T.R. Kurfess, Robotics and Automation Handbook, CRC Press, 2/e, Indian Edition, 2004.

[3] Reference Books/Material:

[4] G. F. Franklin, J. D.Powell and M. L. Workman, Digital Control of Dynamic Systems, Addison Wesley, 1998,Pearson Education,Asia, 3/e, 2000.

[5] K. J.Astroms and B. Wittenmark, Computer Controlled Systems - Theory and Design, Prentice Hall, 3/e, 1997.

Web References:

[1] https://nptel.ac.in/courses/108/105/108105088/

[2] https://www.eolss.net/

Journals References:

[1] Science direct journal of digital control system

[2] IRE Transactions on Industrial Electronics

Title: ROBOTICS/CIM Lab **Code**
L-T-P Scheme: 3-0-0 **Credit: 1**

Objectives

This course is designed to provide practical experience to students with an opportunity of hands-on training on CIM system including CNC machine tools and robots. The topics covered in this course include the basics of automation, NC programming (Manual and APT), concepts of group technology, Flexible Manufacturing system, CIM and robotics etc.

The objective of this course is to expose the students to practical aspects of automation and the state-of-the-art technological developments in the area of modern manufacturing.

Learning Outcome

[1] After completion of this course, the students will have:
[2] Knowledge and operational experience of CNC lathe and milling part programming.
[3] Knowledge and operational experience of programming for robots and CMM
[4] Capability to comprehend the functioning of various components of the automation and CIM.

Learning Outcome:

Course Outcome	Description
CO1	Outline the components and subsystems of robots and basic concepts related to CIM like types of production, automation and FMS.
CO2	Describe the functioning of drive system, end effectors, sensor, and machine vision systems of robots and computer aided process planning (CAPP) and Automated inspection.
CO3	Develop ability to write CNC part programs, formation of part families, pick and place programs for robot and automated inspection through CMM.
CO4	Identify the sequence of operation, generate process plan and simulate the FMS operation in off-line mode.
CO5	Apply acquired knowledge to perform machining, inspection and assembly operations on Flexible manufacturing system available in Robotics/CIM lab of the department.
CO6	Demonstrate ability to work in a flexible manufacturing system in an organization.

Course Content

5-axis and 6-axis Robot

Introduction to 5 and 6 axis robot and basic operations. Write a simple program for pick and place operation for 5-axis robot.

Write program for pick and place operation for repetitive cycle for 5-axis robot.

Write a program for continuous welding operation for 6-axis robot.

Write and practice programming on 6-axis robot.

XL Turn Machine

Write a manual part program for Linear and Circular Contour (G01, G02, and G03) operation for the component. Write a manual part program for Box Facing (G94) operation for the component. Write a manual part program for Multiple Facing (G72) operation for the component. Write a manual part program for Multiple Turning operation with G71 Cycle for the component.

Write a manual part program for Peck Drilling operation with G74 Cycle for the component.

Write a manual part program for Turning and Parting OFF operation through subroutines for the component.

XL Mill Machine

Write a manual part program for Contouring (G01, G02, and G03) operation (Linear & Circular Interpolation) for the component. Write a manual part program for Contouring (G40, G41) operation with Left cutter diameter compensation for the component.

Write a manual part program for Contouring (M98, M99) operation through subprogram for the component. Write a manual part program for Mirroring (M70, M71, M80, and M81) operation for the component.
Write a manual part program for Drilling (G73, G83, G98, and G99) operation for the component.
Write a manual part program for Pocketing (G170, G171) operation for the component.
Coordinate Measuring machine (CMM)
Write a program for automatic measurement of various dimensions such as OD, ID, thickness etc. of a part.
Complete CIM System
Demonstration and study of CIM system Off-line and on-line mode.

Text Book:

[1] Robot programming Manual by MTAB, Chennai
[2] CNC XLTURN Manual by MTAB, Chennai
[3] CNC XLMILL Manual by MTAB, Chennai
[4] Groover M. P., Automation, Production Systems And Computer-integrated Manufacturing, PHI.
[5] Miller R. K., FMS/CIM Systems Integrated Handbook, Prentice Hall

Title: Industrial Automation **Code:**
L-T-P: 3-0-0 **Credit: 3**

Prerequisite: Basic of electrical and electronics engineering, fluid mechanics, kinematics, thermodynamics.

Objective:

This course is a combination of mechanics, electronics and pneumatic/hydraulic.
To impart interdisciplinary knowledge to study conveyors, overhead cranes, robots, pneumatic/hydraulic controls, motors and PLC etc.
The aim of the course is to make a bridge among various engineering disciplines such as Mechanical, Electronics, Instrumentation, Computer and Control to understand automation in industries.

Learning Outcomes:

CO1	Outline of Automated systems to understand the requirement of automation
CO2	Describe various sensors, signal processing, motors, conveyors, robots, PLC, pneumatic and hydraulic systems
CO3	Develop the knowledge of automation to improve the performance of manufacturing, maintenance and assembly units
CO4	Identify the type of sensors, signal conditioning methods and actuators required for specific problem of automation
CO5	Apply the knowledge to develop and maintain various automation systems
CO6	Demonstrate the skill in the field of requirement

Course Content:

Unit I: Automation: Advantages, disadvantages, factory and manufacturing environment.Sensors: Performance terminology, displacement, velocity, acceleration, force, temperature, pressure, flow, light, position and proximity sensors. Signal conditioning and data acquisition.

Unit II: Controllers: Open loop control, close loop control, proportional, derivative, integral, PID and adaptive control. Motors and Conveyors: DC motors, AC motors, stepper motors and servo motors. Belt conveyors, roller conveyors, chain and mat conveyors, indexing and synchronous machines, overhead cranes and industrial robots.

Unit III: Pneumatics and Hydraulics: Flow control, pressure control, none-return, direction and logic control valves. Timers, pressure sequence, counter valves and limit switches. Pneumatic and hydraulic actuators. Multi-actuator circuits, cascade and shift register methods. Solenoid valves, relays, switches, logic control, memory functions, electrical timers and counters, pressure switches.

Unit IV: Programmable Logic Controllers (PLC): Basic structure, input output processing, ladder programming, instruction list, latching, internal relays, sequencing, timers, counters, shift registers, master and jump controls and data handling, Industrial Safety: Hazard analysis, emergency stops, physical guarding, lockout/ tagout, design mitigation, guard devices, software and intrinsic safety.

Teaching Methodology:

The course will start from the architect of automated systems such as inputs and outputs of any physical system. It includes different variety of sensors and the processing of the signals. Also different variety of actuators used in automated systems in the industry to get the required process. It is also required to know the basics of electrical motors and their controls, various modes of controls, conveyors and industrial robots.
In the field of automation pneumatics and hydraulics have their importance. Hence, in this subject different compressor, oil pumps introduction will be given. Different varieties of direction control valves are to be talked to achieve the required action by the actuators. It also includes different architect of the circuits to achieve the required job done. To further enhance the performance of the automation electro-pneumatics will come in action. Further it can be done

to the electro-pneumatics system by incorporating programmable logic controller. It is also deal with various aspects of industrial safety.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit Iand II
Test-2	25 Marks	Based on Unit II, III and syllabus of T1 (20%)
Test-3	35 Marks	Based on Unit III, IV, syllabus of T1 (15%) and syllabus of T2 (15%)
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	100 Marks	

Learning Resources:

Lecture notes on Mechatronics and Automation (will be added from time to time): Digital copy will be available on the JUET server.

Text Book:

[1] HMT Ltd, Mechatronics, Tata McGraw Hill.
[2] Industrial Automation, McGraw Hill Education
[3] References Books/Materials:
[4] Isermann R., Mechatronics Systems: Fundamentals, Springer.
[5] Bradley, D. A., Dawson, D., Buru, N. C. and Loader, A. J., Mechatronics, Chapman and Hall.
[6] Bolton W., Mechatronics, Pearson Education.

Web References:

[1] www.youtube.com/user/nptelhrd

Journals References:

[1] International Journal of Mechatronics and Automation

Title: Control of Industrial Automation **Code:**
L-T-P scheme: 3-0-0 **Credit: 3**

Objectives

The objective of this course is to impart knowledge about automation in production systems. To make students learn the important theoretical concepts, and the state-of-the-art technological developments in the area of automated manufacturing.

Various topics to be covered are basics of automation, NC and CNC technologies, concepts of group technology, Flexible Manufacturing system, CIM and robotics, CAPP, CMM, 3D scanners, automated assembly, Reverse engineering and fundamentals of 3D printing.

Learning Outcome

Course Outcome	Description
CO1	Outline and fundamentals of Industrial automation and importance of automation in Industry 4.0.
CO2	Describe concepts of various types of automation in industries. NC and CNC technologies.
CO3	Develop concept of group Technology, FMS and its components.
CO4	Identify the scope of application of automated assembly, Computer aided process planning and other inspection techniques by studying fundamentals of the same.
CO5	Apply the line balancing algoriths to balance the automated assembly lines. Basic fundamentals of 3D printing and its classification, file formats etc.
CO6	Demonstrate skill to apply reverse engineering in association with 3D printing to create customized parts. 3D printing applications.

Course Content:

Introduction to Automation: Introduction to Production Systems; Automation in Manufacturing and Production Systems: Fixed, Flexible and Programmable Automation, Automation strategies, levels of Automation; Product Development Process and Automation.

Flexible Manufacturing System: Fundamentals of NC and CNC Technology; Concept of Group Technology and Cellular Manufacturing; Flexible Manufacturing Systems and its Components: Workstations, AS/RS, Automated Transport System; Fundamentals of Robotic Systems and Applications.

Computer Aided Process Planning (CAPP): Introduction to process planning, CAPP, generative and retrieval type CAPP.

Automated assembly systems: Design for Automated Assembly, Assembly Line Balancing and examples.

Reverse Engineering: Definition, Scanning and Processing of Raw Data, Creation of CAD Models;

Introduction to Contact and Non-Contact Type Scanners, Types of 3D Optical Scanners and Coordinate Measuring Machine (CMM).

Introduction to 3D Printing: Definition, Processing Steps, Classification, Applications and File Formats for 3D Printing Technology.

Teaching Methodology:

This course is introduced to help students learn and understand various automation techniques being used in Industries. Students will be taught fundamentals of automation and its types, basics of NC and CNC technologies, Group technology, FMS, CAPP, automated assembly, and design for excellence, contact and non contact types inspections techniques, CMM, 3D scanners, reverse engineering, fundamental of 3D printing technology, its classification, material and applications. Although, the course is not complemented by any lab course; students will be taken occasionally to lab for hands on experience.

Evaluation Scheme:

Exams	Marks
Test-1	15 Marks
Test-2	25 Marks
Test-3	35 Marks
Assignment	10 Marks
Tutorials	5 Marks
Quiz	5 Marks
Attendance	5 Marks
Total	100 Marks

Text Books:

[1] Groover M. P., Automation, Production Systems And Computer-integrated Manufacturing, PHI.

[2] Chua, C K, Leong, K F and Lim CS, *Rapid Prototyping: Principles and Applications in Manufacturing*, World Scientific, 2003.

[3] Gibson, I., Rosen, D.W. and Stucker, B., *Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing*, Springer, New York, 2010.

[4] Raja, V. and Fernandes K.J., *Reverse Engineering – An Industrial Perspective*, Springer-Verlag London Ltd, 2008.

Title: Special Purpose Vehicle **Code :**
L-T-P Scheme: 3-0-0 **Credit: 3**

Prerequisite: Student must have already studied courses, "Engineering Thermodynamics, Manufacturing process, Kinematic of Machine, Dynamics of machine, Internal combustion engines and automobile engineering".

Objective:

1. To make aware of the basics of automobile history & its development and Bharat stage requirement in India.
2. To make aware of the role of the SPV in different industrial applications.
3. To learn the different types of special purpose vehicles for commercial and noncommercial applications.
4. To make able to do the analysis of the different common auxiliaries utilized in the SPVs.
5. To develop an understanding of environmental aspect associated with the utilization of internal combustion engine based SPVs.

Learning Outcomes:

Course Outcome	Description
CO1	Outline basis for the categorization of SPVs
CO2	Demonstrate working principals of the auxiliaries associated with the SPVs
CO3	Describe working principals of the Skidder, skipper, loader
CO4	Demonstrate and understand different auxiliary associated with the cooling and lubrication systems
CO5	Develop skill for the performance analysis of CI and SI Engines
CO6	Describe power assisted mechanisms used in SPVs

Course Content

Unit I: Classification of Special Purpose Vehicles: based on applications, wheel types & truck type. Study of working principles & design considerations: of different systems involved like power system, transmission, final drive, lubrication, electrical, braking, steering, pneumatic & hydraulic control circuits.

Unit II: Constructional & working features: of different types of earth moving machinery such as Tippers, shovels, loaders, Excavators, Dumpers, Dozers, Fork Lift truck, Road rollers. Study of instrumentation applied to special purpose vehicles/machines.

Unit III: Farm Tractor: Layout, Load distribution, Engine, Transmission & Drive line, Steering, Braking system, Wheels & Tyres, Hydraulic system, Auxiliary Systems, Draw bar, PTO Shaft. Different types of Implements, accessories and attachments, Tractor trolley.

Unit IV: Mobile Cranes: Basic characteristics of truck cranes, stability & design features, control systems & safety devices.

Unit V: Tracked Vehicles, Articulated Vehicles, Multi-axle Vehicles, fifth wheel mechanism, Semi trailer & Prime mover brakes & electrical systems, Dead Axles, Special Purpose Electric Vehicles, Solar Vehicles and Hybrid Vehicles, Types, architecture and parameters of design considerations

Teaching Methodology:

This is introduced to make the student capable of utilizing skills developed as an outcome from their above-mentioned pre-requisite subjects, various constructional parameters of the child parts and their requirement. Course contain deals within this Special purpose vehicle subject is categorized in five different. Different adequate laboratories viz. Automobile Engineering, Internal combustion Engine, fluid machinery will helps student to examine the performance of different auxiliaries of the SPVs.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1, & Unit-2
Test-2	25 Marks	Based on Unit-3 & Unit-4 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-5 around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	100 Marks	

Learning Resources:

Tutorials and lecture slides of the special purpose vehicle subject (will be added from time to time): Digital copy will be available on the JUET server.

Reference Books:

[1] Obert E.F., Internal Combustion Engines & Air pollution, Hopper & Row Pub., New York.

[2] Heywood J. B., Internal Combustion Engines Fundamentals, McGraw Hill, New York

Web References:

[1] https://www.saeindia.org

[2] http://www.oica.net

[3] https://uia.org

Journals References:

[1] https://www.sciencedirect.com/journal/transportation-research-part-a-policy-and-practice

[2] https://www.sciencedirect.com/journal/journal-of-cleaner-production

[3] https://www.sciencedirect.com/journal/advances-in-engineering-software.