Savitribai Phule Pune University

Faculty of Science & Technology

Curriculum for

Fourth Year

Robotics and Automation

(2019 Course)

(with effect from June 2023)

Savitribai Phule Pune University, Pune
BE (Robotics and Automation)
2019 Course
(With effect from Academic Year 2023-24)

Semester-VII

Course Code	Course Name	Teaching Scheme (Hours/Week)			Examination Scheme and Marks						Credit			
		Theory	Practical	Project	IN-Sem	End-Sem	TW	PR	OR	Total	TH	PR	Project	Total
411501(A)	Machine Vision System	3			30	70					3			3
411502(A)	Robot System Reliability and Safety	3			30	70					3			3
411503(A)	Elective III	3			30	70					3			3
411504(A)	Elective IV	3			30	70					3			3
411501(B)	Machine Vision System Lab		2				25	25				1		1
411502(B)	Robot System Reliability and Safety Lab		2				25	25				1		1
411503(B)	Elective III Lab		2						25			1		1
411504(B)	Elective IV Lab		2						25			1		1
411505	MOOCs						50					2		
411506	Project stage 1			4			50		50				2	1
411507	Mandatory Audit Course 7	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**12**	**8**	**4**	**120**	**280**	**150**	**50**	**100**	**700**	**12**	**6**	**2**	**20**

Elective III

1. Advanced Computational Techniques
2. Wireless sensor network
3. Microprocessor and microcontroller
4. Ergonomics and work management

Elective IV

1. Computational Fluid Dynamics
2. Internet of Things and Machine Learning
3. Artificial Neural Networks and fuzzy systems
4. Power Electronics and Drives

Savitribai Phule Pune University, Pune
BE (Robotics and Automation)
2019 Course
(With effect from Academic Year 2023-24)

Semester-VIII

Course Code	Course Name	Teaching Scheme (Hours/Week)			Examination Scheme and Marks						Credit			
		Theory	Practical	Project	IN-Sem	End-Sem	TW	PR	OR	Total	TH	PR	Project	Total
411508(A)	Field and Service Robots	3			30	70					3			3
411509(A)	PLC and SCADA Programming	3			30	70					3			3
411510(A)	Elective V	3			30	70					3			3
411511(A)	Elective VI	3			30	70					3			3
411508(B)	Field and Service Robots Lab		2				25		50			1		1
411509(B)	PLC and SCADA Programming Lab		2				25		50			1		1
411512	Project stage 2			12			100	50					6	1
411513	Mandatory Audit Course 8	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**12**	**4**	**12**	**120**	**280**	**150**	**100**	**50**	**700**	**12**	**2**	**6**	**20**

Abbreviations:
TH : Theory TW : Term Work PR : Practical
OR : Oral TUT : Tutorial

Elective V
1. Reverse Engineering
2. Data Analytics
3. Entrepreneurship and Innovations
4. Electronics system design and Analysis

Elective VI
1. Additive Manufacturing
2. Industry 4.0
3. VLSI design for Robotics
4. Intelligent Robotics systems

Machine Vision System

411501(A)

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures: 03 hours / week	Theory: 03	In-Sem: 30 Marks End-Sem: 70 Marks

---

Pre-requisites: Basic electronics engineering, Sensors Technology, Robot Programming, Artificial Intelligence for Robotics

Course outcomes:

Student will be able to:

1. Describe the stages of digital image processing
2. Demonstrate the role of image processing in different fields such as robotics, medical, engineering, agriculture, food industry, etc.
3. Apply various machine learning algorithms for image processing and analysis
4. Develop algorithms for machine vision in robotic applications

Unit 1: Introduction to machine vision (7)

Machine vision components - Lighting system, optical system, sensors, steps of vision processing, communications. Machine vision functions – measurement, counting, decoding, and location. Applications of machine vision in automotive industry, manufacturing, electronics, semiconductors, robotics. Benefits of vision system.

Unit 2: Image Acquisition and enhancement (7)

Image acquisition: Image acquisition concept, quantum detectors, Image acquisition models, Charged coupled device (CCD), Complementary metal oxide semi-conductors (CMOS).

Image Enhancement in spatial domain: Point operator, Spatial filter, Linear and non-linear filtering, bilateral filtering, histogram equalization

Image enhancement in frequency domain: 2D Fourier transforms, smoothing frequency domain filters – ideal, butter worth, Gaussian low pass filters.

Unit 3: Image restoration and image compression (7)

Image restoration: Noise reduction by frequency domain filtering, Arithmetic mean filters, geometric mean filters, adaptive filters, Band pass and band reject filters.

Image compression: Steps involved in image compression, Lossless compression techniques – Run length encoding, Huffman encoding, area coding. Lossy compression: Predictive coding, transform coding, wavelet coding. Performance measures of compression – Compression ratio, S/N ratio, speed.

Unit 4: Image segmentation and representation (7)

Image segmentation: Approach based classification – Region based, boundary based. Technique based classification – structural, stochastic, hybrid. Techniques of image segmentation – Thresholding, edge based, watershed, clustering,

Image representations: Colour based image representations, Texture based image representations, Shape based image representation

Unit 5: Motion estimation (7)

Hierarchical motion estimation, Fourier based alignment, incremental refinement, parametric motion, layered motion, Optical flow, Block matching algorithm.

Unit 6: Deep learning algorithms in image processing (7)

Supervised learning algorithms: Bayesian classification, logistic regression, support vector machines. Unsupervised learning algorithms: Clustering, Principal Component Analysis. Deep Neural networks. Convolutional Neural Networks.

References:

1) Richard Szeliski, Computer Vision: Algorithms and Applications, Springer Nature, ISBN: 9783030343729
2) Refael C. Gonzalez and Richard E, Woods Digital Image Processing, Addison-Wesley ISBN: 9780133356724
3) Refael C. Gonzalez and Richard E. Woods, Digital Image Processing Using MATLAB, Addison-Wesley, ISBN: 9780070702622
4) Scott E Umbaugh, Computer Vision and Image Processing Prentice-Hall International, ISBN: 9781439802052
5) Jain A.K., Fundamentals of Digital Image Processing, Prentice-Hall of India, ISBN-100133361659

Robot System Reliability and Safety

411502(A)

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures: 03 hours / week	Theory: 03	In-Sem: 30 Marks End-Sem: 70 Marks

---

Pre-requisites: Engineering Mathematics, Industrial Engineering, Flexible Manufacturing System

Course outcomes:

Student will be able to:

1. To get disciplined approach in order to ensure that a robotic component, product, plant, or process performs its intended function, without failure, for the required time duration in a specified environment.
2. To explore how to behave and survive in robot environment.
3. To get familiar with practical settings which requires maintaining safe operation and consistent performance throughout lifespan of robots, regardless of environmental contact or human interaction

Unit I: Fundamental concepts of Reliability (7)

Reliability terminologies, Role of the reliability function in the organization, Interrelationship of safety,quality and reliability, life characteristic phases, Product liability-Significance, importance of reliability, Introduction to maintainability, availability.

Concepts of Failure, failure density, failure Rate, hazard rate, pdf, cdf. Modes of failure, Mean Time To Failure (MTTF), Mean Time Between Failure (MTBF), Numericals based on calculation of failure rate, hazard rate. Warranty Management and Life cycle cost.

Unit II: Probability Concepts and System Reliability (7)

Basic probability concepts, Laws of probability, Introduction to independence, mutually exclusive,
Conditional probability, Discrete and continuous probability distributions, Comparison of probability distributions -binomial, normal, lognormal, Poisson, Weibull, exponential,
Standard deviation, variance, mean, mode and Central Limit Theorem.
Analysis of series, parallel, mixed configuration systems ,Concept of k- out of n structure, Conditional probability method, delta-star method for conditional probability analysis, Tie-set and Cut Set method (Concepts and Numerical).

Unit III: System reliability Analysis **(7)**

Reliability Improvement- Redundancy, element redundancy, unit redundancy, standby redundancy-types of stand by redundancy, parallel components single redundancy, multiple redundancies (Numericals).

Introduction to Reliability allocation or apportionment, reliability apportionment techniques - equal apportionment, AGREE, ARINC, Minimum effort method (Numericals).

Unit IV: System Reliability Models **(7)**

System reliability–n-component series systems, m-component parallel systems and combined system; standby systems; K-out-of-m systems; redundancy techniques in system design; event space, decomposition (Key Stone), cut and tie sets, Markov analysis.

Unit V: Safety Terminologies, Standards and Regulations **(7)**

Hazard-Types of Hazard- Risk-Hierarchy of Hazards Control Measures-Lead indicators- lag Indicators-Flammability- Toxicity Time-weighted Average (TWA) - Threshold LimitValue (TLV) - Short Term Exposure Limit (STEL)- Immediately dangerous to life or health (IDLH)- acute and chronic Effects- Routes of Chemical Entry-Personnel Protective Equipment- Health and Safety Policy-Material Safety Data Sheet MSDS.

Indian Factories Act-1948- Health- Safety- Hazardous materials and Welfare- ISO 45001:2018 occupational health and safety (OH&S) - Occupational Safety and Health Audit IS14489:1998- Hazard Identification and Risk Analysis- code of practice IS 15656:2006

Unit VI: Workplace Health and Safety **(7)**

Noise hazard- Particulate matter- musculoskeletal disorder improper sitting poster and lifting Ergonomics RULE & REBA- Unsafe act & Unsafe Condition- Electrical Hazards- Crane SafetyToxic gas Release. Preliminary Hazard Analysis-Failure mode and Effects Analysis- Hazard and Operability- Fault Tree Analysis- Event Tree Analysis Qualitative and Quantitative Risk Assessment Checklist Analysis- Root cause analysis- What-If Analysis- and Hazard Identification and Risk Assessment.

Reference Books:

1. Dhillon, B.S., 'Robot System Reliability and Safety: A Modern Approach', CRC Press, Boca Raton, Florida, 2015.
2. Kapur Reliability in engineering Design‖, Wiley india
3. Chandrupatla, ― Quality and Reliability in Engineering‖ Cambridge Uni. Press, India
4. S S. Rao, Reliability Based Design, McGraw Hill Inc. 1992
5. L.S.Srinath, Reliability Engineering, EWP , 4th Edition 2011
6. Frank Lees (2012) 'Lees' Loss Prevention in Process Industries.Butterworth-Heinemann publications, UK, 4th Edition.
7. John Ridley & John Channing (2008) Safety at Work: Routledge, 7th Edition.

Elective III: Advanced Computational techniques

411503(A)

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures: 03 hours / week	Theory: 03	In-Sem: 30 Marks End-Sem: 70 Marks

Pre-requisites: Engineering mathematics-III

Course outcomes:

Student will be able to:

1. Select appropriate computational technique for solving issues in robotics and automation
2. Demonstrate understanding of computational techniques
3. Apply computational techniques for solving models in automation systems
4. Examine the performance of the computational techniques
5. Develop methodology to deal with issues in robotics and automation

Unit 1: System of non-linear equations: (7)

Fixed point iteration for a non-linear system, Newton Raphson method for solving system of non-linear equations, criteria for convergence, error analysis

Unit 2: Fourier approximations: (7)

Curve fitting with sinusoidal functions, Continuous Fourier series, Fourier integral and transforms, Discrete Fourier transforms, Fast Fourier transforms

Unit 3: Boundary value and Eigen value problems: (7)

Shooting method for solving boundary value problems, Finite difference approximation of boundary value problems, Polynomial method to determine Eigen values, power method, LR method and QR method.

Unit 4: Solution of partial differential equations-I: (7)

Finite difference methods:
Parabolic: Forward time central space, Liebmann method, Crank Nicolson method, Hyperbolic: Lax-Friedrichs method, MacCormack method others: Alternating direction-implicit, Finite-difference time-domain Finite volume methods: Monotonic upstream-centered (MUSCL), Riemann Solver

Unit 5: Solution of partial differential equations-II: (7)

Finite element methods: hp-FEM, Discontinuous Galerkin (DG) Meshfree Methods: Smoothed-particle hydrodynamics, Moving particle semi-implicit method

Unit 6: Advanced optimization techniques: (7)

Sequential quadratic programming, Genetic algorithms, simulated annealing. Application to solve inverse kinematics problems.

References:

1) Smith G.D. "Numerical solutions for Differential Equations" Mc Graw Hill, ISBN 978-3-319-06922-7
2) Chapra S.C. and Canale R.P. "Numerical Methods for Engineers" Mc Graw Hill 2006. ISBN-13. 978-0073401065
3) Ketter and Prawel "Modern Methods for Engineering Computations" Mc Graw Hill, ISBN 0 07 0992746.
4) Rajasekharan S. "Numerical Methods for Initial and Boundary value problems," Khanna publishers 1989.
5) S.S. Rao, Optimisation Theory and applications, Wiley Eastern, ISBN, 0852267568,

Elective III: Wireless Sensor Network

411503(A)

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures: 03 hours / week	Theory: 03	In-Sem: 30 Marks End-Sem: 70 Marks

Course Outcomes:

On completion of the course, students will be able to

1. Explain various concepts and terminologies and protocols used in wireless sensor networks (WSN).
2. Describe importance and use of radio communication and link management in WSN
3. Recognize importance of localization and routing techniques used in WSN.
4. Apply techniques of data aggregation and importance of security in WSN.
5. Examine the issues involved in design and deployment of WSN.

Unit I: Introduction (7)

What are Wireless Sensor Networks, Wireless Sensor Node, Anatomy of a Sensor Node, Architecture of WSN, Performance metrics in WSN, types of WSN.

Unit II: Radio Communication & Link Management (7)

Radio Waves and Modulation/ Demodulation, Properties of Wireless Communications, Medium Access Protocols, Wireless Links Introduction, Properties of Wireless Links, Error Control, Naming and Addressing, Topology Control.

Unit III: Wireless Standards & Protocol Stack (7)

WSN Standards- IEEE802.15.4 low rate WPAN, Zigbee, Wireless HART, ISA 100.11a, 6LoWPAN, IEEE802.15.3, Wibree, BLE, Zwave, ANT, Insteon, Wavenis, Protocol stack of WSNs, Cross Layer Protocol Stack

Unit IV: Localization & Routing **(7)**

Localization: Localization Challenges and Properties, Deployment Schemes, Proximity Schemes, Ranging Schemes, Range-Based Localization, Range-Free Localization, Routing Basics, Routing Metrics, Routing Protocols, Full-Network Broadcast, Location-Based Routing, Directed Diffusion, Collection Tree Protocol, Zigbee, Multi-Hop Communications

Unit V: Data Aggregation & Security **(7)**

Clustering Techniques, In-Network Processing and Data Aggregation, Compressive Sampling, Security Issues in Wireless Sensor Networks, Attacks, Defensive Measures, Security requirements and threat model.

Unit VI: Designing & Deploying WSN Applications (7)

Designing and Deploying WSN Applications, Early WSN Deployments, General Problems, General Testing and Validation, Requirements Analysis, Top-Down Design Process, Bottom-Up Implementation Process.

References:

1. Dargie W. and Poellabauer C., "Fundamentals of Wireless Sensor Networks: Theory and Practice," John Wiley and Sons.
2. Anna Hac, "Wireless Sensor Network Designs," John Wiley and Sons.
3. Holger Karl and Andreas Willig, “Protocols and Architectures for Wireless Sensor Networks,” John Wiley and Sons.
4. Edgar H. Callaway Jr. and Edgar H. Callaway, "Wireless Sensor Networks: Architectures and Protocols," CRC Press.
5. Sohraby K., Minoli D. and Znati T., "Wireless Sensor Networks: Technology, Protocols and Applications,” John Wiley and Sons.

Elective-III: Microprocessor and Microcontroller

411503(A)

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures: 03 hours / week	Theory: 03	In-Sem: 30 Marks End-Sem: 70 Marks

---

Prerequisites: Basic Electronics Engineering, Control System Engineering

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

1. Recall basic concept of digital fundamentals to Microprocessor based personal computer system.
2. Identify a detailed software and hardware structure of the Microprocessor.
3. Illustrate how the different peripherals (8259, 8255, 8253 etc.) interfaced with Microprocessor.
4. Distinguish and analyze the properties of Microprocessors & Microcontrollers.
5. Analyze the data transfer information through serial & parallel ports.

Unit 1: Introduction to 8085 Microprocessor (7)

Architecture CPU, address bus, data bus and control bus. Input/output devices, buffers, encoders, latches and memories. Internal Data Operations and Registers, Pins and Signals, Peripheral Devices and Memory Organization, Interrupts, Classification, Format and Timing.

Instruction Set: 8 Bit and 16 Bit Instructions, Programming and Debugging, Subroutines

8085 Microprocessor Interfacing 8259, 8257, 8255, 8253, 8155 chips and their applications. A/D conversion, memory, keyboard and display interface (8279).

Unit 2: Introduction to 8086 Microprocessor (7)

Architecture of INTEL 8086 (Bus Interface Unit, Execution unit), register organization, memory addressing, memory segmentation, Operating Modes

Instruction Set of 8086: Addressing Modes: Instruction format: Discussion on instruction Set: Groups: data transfer, arithmetic, logic string, branch control transfer, processor control. Interrupts: Hardware and software interrupts, responses and types.

Unit 3: Microcontroller 8051 **(7)**

Introduction and history of microcontrollers. Features of 8051 microcontroller. Block diagram of 8051- program status word (PSW), accumulator, and program counter. Memory organization – RAM & ROM, register banks and stack, Pin out diagram- description of pins, special function registers (SFRs), I/O port organization, interrupts.

Instruction Set of 8051 & addressing modes

Classification of instruction set - Data transfer group, arithmetic group, logical group, single bit, branching group, CALL and RET instructions and their usage. Addressing modes - Immediate, register, direct, register indirect and indexed addressing modes. Accessing the data from internal and external memory. Signed number concepts, generating relative address for loops.

Unit 4: PIC 18F XXXX Microcontroller Architecture **(7)**

Comparison of PIC family, Criteria for Choosing Microcontroller, features, PIC18FXX architecture with generalized block diagram. MCU, Program and Data memory organization, Bank selection using Bank Select Register, Pin out diagram, Reset operations, Watch Dog Timers, Configuration registers and oscillator options (CONFIG), Power down modes , Brief summary of Peripheral support, Overview of instruction set.

Unit 5: Real World Interfacing with Cortex M4 Based Microcontroller **(7)**

GPIO Programming, Interfacing seven segment LED, LDR and MQ3 sensor with STM32F4xx, STM32F4xx: Counters and Timers: Timer and Delay Generation, UART Programming, on chip ADC and On chip DAC for waveform generation.

Unit: 6 Microprocessor and Microcontroller applications in the field of Robotics **(7)**

Development of a Microcontroller Based Robotic Arm, Application of Multipath Servo in Industrial Robot Control System, Unmanned Vehicle Design using Microcontroller, Mobile Robot Analysis and Control for Pipe Line Inspection.

References:

1. Kenneth J. Ayala, ‘The 8051 Microcontroller Architecture, Programming and Applications’, Cengage Learning, 3 rd Edition, ISBN 0-314-77278-2
2. Ajay Deshmukh, “Microcontrollers Theory and Applications”, TATA McGraw Hill, 4th Edition, ISBN 10: 0070585954. ISBN 13: 9780070585959.
3. Peatman, John B, “Design with PIC Microcontroller”, Pearson Education PTE, 1 st Edition.
4. Data Sheet of PIC 18FXXXX series.
5. R. S. Gaonkar, “Microprocessor Architecture: Programming and Applications with the 8085/8080A”, Penram International Publishing, Third Edition, 1996.
6. D A Patterson and J H Hennessy, "Computer Organization and Design The hardware and software interface” Morgan Kaufman Publishers, Fourth Edition, 2011.

7. Douglas Hall, “The Microprocessors and its Interfacing”, Tata McGraw Hill, Third Edition, 2012.
8. Kenneth J. Ayala, “The 8051 Microcontroller: Architecture Programming & Applications”, Penram International Publishing, Second Edition, 1996
9. Yu-Cheng Liu, Glenn A. Gibson, “Microcomputer Systems: The 8086 / 8088 Family - Architecture, Programming and Design”, Second Edition, Prentice Hall of India, 2011.

Elective III: Ergonomics and Work Management
411503(A)

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures: 03 hours / week	Theory: 03	In-Sem: 30 Marks End-Sem: 70 Marks

Pre-requisites: Industrial Engineering and Management

Course Outcomes:
After learning this subject, the student will be able to:
1. Analyze man machine interaction system for human comfort.
2. Evaluation of physiological functions for preventing accidents.
3. Application of anthropometry in practical life.
4. Demonstrate productivity improvement techniques.

UNIT I: Introduction **[7]**
Ergonomics: Introduction, history of development, man-machine system and its components. Introduction to structure of the body- features of the human body, stress and strain, and metabolism.

UNIT II: Measure of physiological functions **[7]**
Workload and energy consumption, biomechanics, Types of movements of body members, strength and endurance, speed of movements. NIOSH lifting equation, Lifting Index, Maximum acceptable Weights and Forces, Distal upper extremities risk factors, Strain Index, Rapid Upper Limb Assessment (RULA), Rapid Entire Body Assessment (REBA).

UNIT III: Applied anthropometry **[7]**
Types, use, principles in application, design of work surfaces and seat design. Visual displays for static information, visual displays of dynamic information, auditory, tactual and olfactory displays and controls. Assessment of occupational exposure to noise, heat stress and dust. Effect of vibration/ noise, temperature, illumination and dust on human health and performance.

UNIT IV: Human Factors and Ergonomics in Consumer Product Design
Techniques to Translate Design Research into Useful, Usable, and Desirable Products, stages of design research**,** *Collect the Data,* interpret the Data**,** Model-Based Framework for Influencing Consumer Products, Addressing Human Factors and Ergonomics in Design Process, Product Life Cycle, and Innovation: Trends in Consumer Product Design Conceptual Designs, Framework for Integrating Environmental Issues in Ergonomics to Product Development, Cultural Ergonomics Issues in Consumer Product Design.

UNIT V: Work Management **[7]**
Productivity, work content, techniques to reduce work content. Method study, micro motion study, work-measurement: MTM and MOST, Lean manufacturing, 5S, Kaizen, Poka- Yoke, Kanban, Manpower planning

nit VI: Industrial Safety and Management [7]

History and development of Industrial safety: Implementation of factories act, Formation of various councils, Safety and productivity, Safety organizations. Safety committees, safety committee structure, Roll of management and roll of Govt. in industrial safety, Safety analysis. Personal protective equipment, Survey the plant for locations and hazards, Part of body to be protected, Education and training in safety, Prevention causes and cost of accident, Housekeeping, First aid, Firefighting equipment, Accident reporting, Investigations, Industrial psychology in accident prevention, Safety trials. Features of Factory Act, ESI Act, Workman's compensation Act, Industrial hygiene, Occupational safety, Diseases prevention, Ergonomics, Occupational diseases, stress, fatigue, health, safety and the physical

References

1. Mark. S. Sanders and Ernest. J Mc Cornick, Human Factor in Engineering and Design
2. Mc Graw-Hill Book Co., 49 Inc., New York, ISBN 0-07-054901-X
3. Waldemar Karwowski, Marcelo M. Soares, and Neville A. Stanton, Human Factors and Ergonomics in Consumer Product Design: Volume I: Methods and Techniques, CRC Press, Taylor & Francis Group, Boca Raton London New York, International Standard Book Number-13: 978-1-4200-4629-8 (eBook - PDF)
4. **J**an Dul and Bernard Weerdmeester, Ergonomics for Beginners A quick reference guide, Second edition, Taylor & Francis Group,London and Newyork, ISBN 0-203-21209-6
5. Kieii B. Zandin, Maynard's Industrial Engineering Handbook, McGraw-Hill, ISBN:9780070411029
6. Introduction to Work Study – ILO International Labour Organization 4th edition 1992, ISBN 92-2-107108-1

Elective-IV: Computational Fluid Dynamics

411504 (A)

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures: 03 hours / week	Theory: 03	In-Sem: 30 Marks End-Sem: 70 Marks

---

Pre-requisites: Basic course on Fluid Mechanics, Thermodynamics and Numerical Methods

Course outcomes:

Student will be able to:
1. Demonstrate the basic concepts of CFD.
2. Apply the various discretization methods, solution procedures to solve flow problems.
3. Use various turbulence models to solve turbulent flow problems.
4. Categorize different numerical techniques used to solve fluid flow problems.

Unit 1: Introduction to CFD & Principles of Conservation (6)

Introduction to CFD, Theoretical and Numerical Approach, Historical Background, Applications of CFD, Fundamental principles of conservation, Reynolds transport theorem, Conservation of mass, Navier-Stokes equation, Conservation of Energy

Unit 2: Finite Difference Method & Discretization (6)

Basics of Discretization (Finite Difference Method-FDM, Finite Volume Method-FVM & Finite Element Method-FEM), Finite Difference: Introduction, Finite Difference representation of PDEs (Partial Differential Equations), Truncation error, Round-off error, Discretization error, Explicit and Implicit Methods, Stability analysis, TDMA (Tridiagonal matrix algorithm), ADI (Alternative Direction Implicit) method, First order Upwind scheme, Lax–Wendroff method, Second order Upwind scheme.

Unit 3: Finite Volume Method for steady diffusion problems (6)

Basic concepts of Finite Volume method (FVM), Finite Volume method for 1-D steady state diffusion type problem, Finite Volume method for 2-D steady state diffusion type problem, Types of Boundary Conditions, Different advection schemes

Unit 4: Numerical Solutions of Navier-Stokes Equations (6)

Discretization of the Momentum Equation, Stream Function-Vorticity approach and Primitive variable approach, Staggered grid and Collocated grid, SIMPLE Algorithm, SIMPLER Algorithm, SIMPLEC Algorithm, PISO Algorithm

Unit 5: Numerical Grid Generation (6)

Definition of Grid, need for grid, Geometric modelling and surface grid, Algebraic grid generation, Automatic generation of unstructured grid, Structured and Unstructured grid, Multi Block grid, Types of grid element, factors affecting the grid

Unit 6: Application of CFD and Future scope (6)

Recent trends in CFD, Application of CFD: for Battery Simulation, Simulating Aerodynamics, Heat Transfer and Thermal Management Simulation, Pipe and Valve Simulation, Simulating Electronics Cooling using CFD, Computer graphics in CFD, The future of CFD: Enhancing the Design process, Enhancing understanding

References:

1) Anderson J.D., Computational Fluid Dynamics: The Basics with Applications, McGraw-Hill Inc., ISBN: 0-07-001685-2
2) Anderson, D.A., Tannehill, J.C. and Pletcher, R.H., Computational Fluid Mechanics and Heat Transfer, Taylor & Francis, ISBN: 1-56032-046
3) Versteeg, H. K. and Malalasekara, W., Introduction to Computational Fluid Dynamics: The Finite Volume Method. Second Edition (Indian Reprint) Pearson Education, ISBN: 0131274988
4) T. J. Chung, Computational Fluid Dynamics, Cambridge University Press., ISBN: 0521769698
5) S. V. Patankar, Numerical Heat Transfer and Fluid Flow, McGraw-Hill, ISBN:0-07-048740-5

Elective IV: Internet of Things and Machine Learning

411504 (A)

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures: 03 hours / week	Theory: 03	In-Sem: 30 Marks End-Sem: 70 Marks

Pre-requisites: Statistics and Numerical Methods, Sensors Technology, Basic Electronics, Artificial Intelligence for Robotics

Course outcomes:

Student will be able to:

1. Demonstrate the concepts of Internet of things (IoT) and its applications
2. Make use of embedded system platform to develop sensor-based applications
3. Identify machine learning algorithm for given application
4. Deploy machine learning algorithm
5. Implement the concept of Cloud and Fog computing in robotics

Unit 1: Introduction to IoT

Concepts and Definitions of The Internet of Things (IoT), History of IOT, High level IoT Architecture, The major component of IoT (Hardware & Software), IoT communication and networking protocols, Role of wired and wireless communication, IoT services and applications, Challenges in IoT implementation and concept of Real time Operating System,

Unit 2: Network and Communication aspects

Access Point (AP) in Wireless LAN, Target Wake Time (TWT), MAC protocol survey, Survey routing protocols, Sensor deployment & Node discovery, Data aggregation & dissemination.

IoT Communication Protocols - Message Queuing Telemetry Transport (MQTT), ZigBee, Bluetooth, Constrained Application Protocol (CoAP), User Datagram Protocol (UDP), Transmission Control Protocol (TCP).

Unit 3: IOT Data Storage & Retrieval

Overview and Role of Storage in Cloud / Server /Inhouse Storage, Databases Connectivity with IOT and uses, Wireless medium access issues, Analysis of data using Ipython Module, Data Cleaning in IoT, Application Programming Interfaces (API) overview.

Unit 4: Machine Learning overview:

Motivation and role of machine learning in Robotics and Automation, ML Techniques overview, Machine learning Life cycle, Difference between Artificial intelligence and Machine learning, gathering and pre-processing of Data, clustering in ML, Confusion Matrix in ML, Overfitting and Underfitting in ML, Association Rule Learning, Application of ML in Robotics and Automation industries.

Unit 5: Networking with ESP8266 WiFi module

Using Arduino IDE, Introduction to ESP8266 Wi-Fi Module, Various Wi-Fi library, Web server-introduction, installation, configuration, Posting sensor(s) data to web server, Interfacing ESP8266 with Web services

Unit 6: IoT in real world:

Smart Metering, e-Health Body Area Networks and patient movement trackers, Automotive Applications (connected cars/smart cars etc.), Home Automation/smart homes, Agriculture - crop health monitoring and automating the irrigation system. Role of Iot/IIoT in smart City

References:

1) Vijay Madisetti, Arshdeep Bahga, “Internet of Things: A Hands-On Approach” 2014. ISBN: 978-0996025515
2) Jamil Y. Khan, Mehmet R. Yuce, “Internet of Things (IoT): Systems and Applications”, CRC Press, 2019, ISBN: 9780429678059
3) BK Tripathy, J Anuradha, “Internet of Things (IoT): Technologies, Applications, Challenges and Solutions”, CRC Press, 2017. ISBN: 9781351980296
4) Ethem Alpaydin “Introduction to Machine Learning Adaptive computation and machine learning”, MIT Press, 2004, ISBN: 9780262012119
5) Miroslav Kubat, “An Introduction to Machine Learning”, Springer, 2017. ISBN: 9783319639130

Elective IV: Artificial Neural Networks and Fuzzy systems

411504 (A)

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures: 3 hours / week	Theory: 03	In-Sem: 30 Marks End-Sem: 70 Marks

---

Pre-requisites: Engineering Mathematics, Artificial Intelligence for robotics

Course Outcomes:
After learning the course the students should be able to:

1. Develop Fuzzy Inference System for various applications.
2. Integrate and develop Neural Network for various applications.
3. Illustrate the role played by Mechatronics engineers to automate the process by integrating the knowledge of soft-computing techniques.

Unit I: Neural Networks: Introduction (7)
Humans and Computers, Organization of the Brain, Biological Neuron, Biological and Artificial Neuron Models, Hodgkin-Huxley Neuron Model, Integrate-and-Fire Neuron Model, Spiking Neuron Model, Characteristics of ANN, McCulloch-Pitts Model, Historical Developments, Potential Applications of ANN. Neuron, Nerve structure and synapse, Artificial Neuron and its model, activation functions,

Unit II: Essentials of Artificial Neural Networks (7)
Artificial Neuron Model, Operations of Artificial Neuron, Types of Neuron Activation Function, ANN Architectures, Classification Taxonomy of ANN – Connectivity, Neural Dynamics (Activation and Synaptic), Learning Strategy (Supervised, Unsupervised, Reinforcement), Learning Rules, Types of Application

Unit III: Neural Networks Architecture (7)
Single layer and multilayer feed forward networks, recurrent networks. Various learning techniques; perception and convergence rule, Auto-associative and hetro-associative memory**,** perceptron model, solution, single layer artificial neural network, multilayer perception model; back propagation learning methods, effect of learning rule co-efficient ;back propagation algorithm, factors affecting back propagation training, applications

Unit IV: Fuzzy Logic: Introduction (7)
Basic concepts of fuzzy logic, Fuzzy sets and Crisp sets, Fuzzy set theory and operations, Properties of fuzzy sets, Fuzzy and Crisp relations, Fuzzy to Crisp conversion

Unit V: Fuzzy Logic: Fuzzy Membership, Rules (7)
Membership functions, interference in fuzzy logic, fuzzy if-then rules, Fuzzy implications and Fuzzy algorithms, Fuzzyfications & Defuzzificataions, Fuzzy Controller, Industrial applications.

Unit VI: Fuzzy Logic Applications **(7)**

Operations of Fuzzy relation, Defuzzification, Fuzzy rule base and approximate reasoning, Fuzzy Inference Systems, Design a fuzzy logic controller: Mamdani and Sugeno Architecture

References:

1. S. Rajsekaran & G.A. Vijayalakshmi Pai, "Neural Networks,Fuzzy Logic and Genetic Algorithm:Synthesis and Applications" Prentice Hall of India, *ISBN* 9788120321861
2. N.P.Padhy,"Artificial Intelligence and Intelligent Systems" Oxford University Press, *ISBN* 0- 321-53735-1
3. Siman Haykin, "Neural Netowrks" Prentice Hall of India, ISBN-108131763773
4. Timothy J. Ross, "Fuzzy Logic with Engineering Applications" Wiley India, ISBN- 978-8126513376
5. Kumar Satish, "Neural Networks" Tata Mc Graw Hill, ISBN-0070482926
6. Bart Kosko Neural Networks and Fuzzy Logic System, PHI Publications, ISBN-978-8120308688 ISBN- 9788120308688

Elective IV: Power Electronics and Drives

411504 (A)

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures: 03 hours / week	Theory: 03	In-Sem: 30 Marks End-Sem: 70 Marks

Prerequisites: Basic electronics engineering, Basic electrical engineering**,** Electronics Engineering and Electrical technology

Course Outcomes:

The course should enable the students to:

1. Examine the characteristics of various devices and application of firing circuits used in power electronics.
2. Analyze the performance characteristics of AC voltage regulators, choppers, inverters, rectifiers and cyclo converters.
3. Demonstrate the working principle of various power electronic devices and circuits using simulation.
4. Design the simple power electronic circuits through digital simulation.
5. Provide strong foundation for study of power drives and their applications.

Unit no 1: Power Semiconductor Devices (7)

Introduction, Scope and Application, Classification of Power Converters, Construction and characteristics of Thyristors, MOSFET, IGBT, IGCT and GTO, etc. Comparison of Controllable switches.

Unit no 2: Phase Controlled (AC to DC) Converters (Rectifiers) (7)

Principle of phase control, Full-wave controlled Converters. Single phase full wave converters, Single phase two pulse converters with discontinuous load and its performance, three phase thyristor converters: half wave, full and semi converters. Dual Converters. Effect of source impedance on performance of converter.

Unit no 3: DC to DC Converters (Choppers) (7)

Introduction, Classification, Principle and Operation, Control strategies, Chopper configurations, Thyristor chopper circuits, Jones chopper, Morgan chopper, AC (Multiphase) chopper, Switched mode power supply: step down (buck), Step up (boost) and step down/step up (buck/boost) converters.

Unit no 4: DC to AC Converters (INVERTERS) (7)

Introduction, Classification, single phase half and full bridge VSI, three phase VSI 120 and 180 degree conduction mode. Performance Parameters of Inverter, Voltage control of single phase and three phase Inverter, Series inverter, Parallel inverter, Current source inverter.

Unit no 5: AC Voltage Controllers **(7)**

Introduction, Principal of On-Off control and Phase Control, Single phase Bidirectional Controllers with R and R-L Loads, Three phases full wave controllers. Cycloconverters: Single Phase and Three phase Cycloconverter and Matrix Converter

Unit no 6: Power Drives **(7)**

Application of Power Electronics: D.C. Motor Speed control, A.C. Drives: variable frequency drives. AC Voltage Regulators. Need of variable speed drives, Review of speed control methods in DC and AC drives, role of electrical drives in energy conservation, classification of electrical drives, four-quadrant operation of electrical drives, stability of electrical drives.

References:

1. Ned Mohan, Tore M. Undeland, 'Power electronics: converters, applications, and design', John Wiley &Sons. 3 rd edition.
2. P. S. Bimbhra, "Power Electronics", Khanna Publishers, New Delhi.
3. M.D. Singh, K B Khanchandani, 'Power Electronics', second edition, TATA McGraw Hill.
4. Muhammad H. Rashid, "Power Electronics - circuits, devices and applications", Prentice Hall of India, 2nd edition.
5. Vedam Subramanyam, "Power Electronics – Devices, Converters and Applications", Revised 2nd edition, New Age Publications.
6. Dubey, Joshi and Doradla, "Thyristorised controller", New age Publication.
7. B. K. Bose, 'Modern Power Electronics & AC Drives', Prentice Hall India.

Machine Vision System Lab

411501(B)

Credit Scheme	**Credit Scheme**	**Examination Scheme**
Practical: 02 hours / week	PR: 01	TW: 25 Marks PR: 25 Marks

List of practical

1. Introduction to OpenCV and accessing the image elements.
2. Basic Image Handling and processing operations on the image
3. Programming for Perspective Transformation
4. Camera Calibration for robot vision system
5. Program for Image enhancement and image compression
6. Program for Edge Detection of a given object using image processing
7. Color and shape identification using machine vision
8. Application of deep learning algorithms for machine vision

Robot System Reliability and Safety Lab

411502(B)

Teaching Scheme	Credit Scheme	Examination Scheme
Practical: 2 hours / week	Practical: 01	PR: 25 Marks
		TW: 25 Marks

Term Work

The term work shall be based on the following assignments:

1. Study of reliability models of complex systems for robots and automation
2. Study and analysis of discrete and continuous probability distributions.
3. Case study on MTTF and MTBF.
4. To analyze the reliability factors related to industrial robots
5. Experimental study of robot accuracy and reliability using LVDT
6. To conduct a trial on any one robot and write report on safety precautions and maintenance to be done.
7. To study robot safety tools and devices.
8. Industrial visit report on study of reliability and safety measures.

Elective-III: Advanced Computational techniques Lab

411503 (B)

Teaching Scheme	**Credit Scheme**	**Examination Scheme**
Practical: 02 hours / week	Practical: 01	OR: 25 Marks

Implement C/ Matlab program for the following to any case study related to robotics and automation:

1. Newton Raphson method for solving system of non-linear equations
2. Fast Fourier transforms for curve fitting
3. Shooting method for solving boundary value problems
4. Solution of partial differential equations using finite difference method
5. Solution of partial differential equations using finite element method
6. Solution of constraint optimization problem using genetic algorithm/simulated annealing

Elective-III: Wireless Sensor Network Lab

411503(B)

Teaching Scheme	**Credit Scheme**	**Examination Scheme**
Practical: 02 hours / week	Practical: 01	OR: 25 Marks

Oral will be based on following Topics

1. Introduction to Wireless Sensor Networks
2. Experiment on RF communication using Wireless sensor nodes
3. Wireless Sensor Network Duty Cycle Implementation vs. Analysis of Power Consumption
4. Wireless Sensor Network Data Collection Frequency and transmission vs. Analysis of Power Consumption
5. Analysis of real time exposure on the wireless propagation effects
6. Wireless sensor network topologies and experiment data sending and reception at various power levels- Application to any robotics system

Elective- III: Microprocessor and Microcontroller Lab

411503(B)

Teaching Scheme	Credit Scheme	Examination Scheme
Practical: 02 hours / week	Practical: 01	OR: 25 Marks

Lab Experiments

1. Interfacing a simple blinking LED with 8085 Microprocessor.
2. Interfacing a simple Keyboard with 8085 Microprocessor.
3. To write an assembly language program to perform arithmetic operations using 8086 Microprocessor.
4. Write a Program for interfacing of LCD to 8051 microcontroller in 8 bit mode.
5. Write a program for interfacing of stepper motor to 8051 Microcontroller .
6. To Interface button,LED,relay and buzzer to PIC Microcontroller.
7. Generate square wave using timer with interrupt of PIC Microcontroller.
8. Generation of PWM signal for DC motor control with any Microprocessor
9. Interface of serial port of PIC microcontroller with PC and perform serial communication.
10. To interface keyboard to PIC microcontroller and display key pressed without using any standard library function for keyboard .

Elective III: Ergonomics and Work Management
411503(B)

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures: 02 hours / week	Practical: 01	Oral: 25 Marks

Pre-requisites: Industrial Engineering and Management

---

1. Case study on RULA,
2. Case study on REBA.
3. Case study on design of work area
4. Case study on Ergonomics and Environmental consideration in Consumer Product Design
5. Case study on 5S/ Kaizen/Poka- Yoke/Kanban/Charts used in method study with illustration(any one)
6. Case study on Industrial Safety

Elective-IV: Computational Fluid Dynamics Lab

(411504 B)

Credit Scheme	**Credit Scheme**	**Examination Scheme**
Practical: 02 hours / week	Oral: 01	Oral: 25 Marks

Implement C/ CPP program for the following to case study related to computational fluid dynamic. Oral will be based on any four assignments from following.

1. Heat Transfer Analysis of Heat Sink by Computational Fluid Dynamics using Finite Difference Method (FDM) or by using Finite Volume Method (FVM)
2. Solution of Heat Equation by Explicit Finite Difference Method (FDM)
3. Solution of Heat Equation by Implicit Finite Difference Method (FDM)
4. Solution of Electronics Cooling by Finite Difference Method (FDM)
5. Solution of Wave Equation by Finite Difference Method (FDM)
6. Solution of Heat Equation by Finite Volume Method (FVM)

Elective IV: Internet of Things and Machine Learning Lab

411504 (B)

Teaching Scheme	Credit Scheme	Examination/Marking Scheme
Practical: 02 hours / week	Practical: 01	Oral: 25 Marks

List of Experiments:

1. Understanding Internet of things environment and installing IDE.
2. Getting started with virtual IoT project development using virtual simulator.
3. Arduino Programming for LED blinking and RGB LED.
4. Develop Automatic Plant watering system using Arduino.
5. Develop Automatic Railway Gate Control system using Arduino .
6. Develop a project to send data (any sensor data) to cloud using ESP8266.
7. Develop home automation system using ESP8266.
8. Implement a Machine Learning Algorithm for any two objects detection.
9. Case study on Machine Learning Algorithms used in image processing.
10. Case study on Machine Learning Algorithms used in Robotics.

Elective IV: Artificial Neural Networks and Fuzzy systems Lab

411504 (B)

Credit Scheme	**Credit Scheme**	**Examination Scheme**
Practical: 02 hours / week	OR: 01	OR: 25 Marks

List of practical

1. Case study of Feature of EEG Signals
2. Case study of image decryption using neural networks
3. Case study on internal fault identification using artificial neural network
4. Case study on speaker recognition using soft computing
5. Case study on smart driver assist system using raspberry-pi
6. Case study on face identification system using ANN
7. Case study on electronic music system using ANN
8. Case study on automation of traffic signal using raspberry-pi
9. Case study on digital audio watermark embedding system
10. Case study on signature forgery and handwriting detection system

Elective IV: Power Electronics and Drives Lab

411504(B)

Teaching Scheme	**Credit Scheme**	**Examination Scheme**
Practical: 02hours / week	Practical: 01	OR: 25 Marks

List of Experiments:

1. Study of 1-phase AC to DC controlled converter (both fully controlled and half controlled).
2. Study of 3- phase AC to DC full controlled converter.
3. Study of a TRIC based single phase AC regulator and determination of Thyristor switching characteristics and pulse transformer characteristics.
4. Study of Thyristor based DC to DC converter (DC chopper).
5. Study of a 3-phase PWM inverter with fixed (50 Hz) output frequency and study of a non-PWM type inverter with 120-degree conduction of switches.
6. Study of an inverter fed adjustable speed drive for a 3-phase induction motor.
7. Study of a Thyristor based DC-drive with closed loop speed control.
8. MOSFET based DC to DC converter (buck, boost and buck-boost types with non isolated output voltage.).
9. Study of an industrial type fly-back DC to DC converter with isolated and regulated output voltage.
10. Study of a single phase PWM AC to DC converter.
11. Study of 1-phase ASCI (Auto Sequential Commutated Inverter) current source inverter.

MOOCs

411505

Teaching Scheme	Credit Scheme	Examination Scheme
NA	Practical: 02	TW: 50 Marks

Students should complete any one of the following MOOCs courses: The assessment will be either based on the online score obtained in that course or by giving the assignments on the course chosen by the student.

1. Developing Soft Skills and personality
2. Enhancing Soft Skills and personality
3. Spearing Effectively 8 Weeks
4. Introduction to Industry 4.0 and Industrial Internet of Things
5. Emotional Intelligence.
6. Patent Law for engineers and Scientist.

Project Phase-I

411506

Teaching Scheme	Credit Scheme	Examination Scheme
Project: 04 hours / week	Project: 02	TW: 50 Marks OR: 50 Marks

---

Pre-requisite:

1. Students are required to undergo 3 to 4 weeks industrial training / implant training /in-house project based learning/project related skill development course/ industrial survey report before commencement of first semester of Final year.
2. Submit detailed report of 10-15 pages of the same.
3. Project registration will be based on completion of above activities.

The student shall take up a suitable project, the scope of the project shall be such as to complete it within the time schedule, and the term work shall consist of:

Fabrication of models, machines, prototypes based on new ideas, robots and machine based on hi-tech systems and automation, experimental set-up, fabrication of testing equipment, renovation of machines, etc. Students shall submit the project phase –II plan. Above work shall be taken up individually or in groups. The group shall not be more than 4 students, (If project work is more then group members may be increased by permission of guide)

OR

Extensive analysis of some problems done with the help of a computer individually or in a group not exceeding two students.

A detailed report on the work done shall include project specification, design procedure, drawings, process sheets, assembly procedure and test results etc. Project may be of the following types:

(i) Manufacturing / Fabrication of a prototype machine' including selection, concept, design, material, manufacturing the components, assembly of components, testing and performance evaluation
(ii) Improvement of existing machine / equipment / process.
(iii) Design and fabrication of robots for specialized applications,
(iv) Computer aided design, analysis of components such as stress analysis.
(v) Problems related to Automated Storage and retrieval system
(vi) Design of a test rig for performance evaluation of machine devices.
(vii) Design and development. of non-standard robots
(viii) Analysis, evaluation and experimental verification of any engineering problem
(ix) Design and development of service robots
(x) Hardware system development to ingrate robotics operations

(xi) Low cost automation, Computer Aided Automation in Manufacturing.
(xii) Development of prototypes for new concepts in robotics such as biological robots, swarm robotics, drones, humanoids
(xiii) Development of artificial intelligence systems for humanoids and robots

OR

Computer based design / analysis or modelling / simulation of robot(s), mechanism(s) or system (s) and its validation or comparison with available benchmarks / results. When a group of students is doing a project, names of all the students shall be included on every certified report copy. Two copies of project Report shall be submitted to the college. The students shall present and submit their Project Phase-I report to the internal and external examiner from college/Industry.

Audit Course 7: Human Rights

411507

Course outcomes

After completing the course the students will be able to:

1. Realize the importance and different approaches to Human rights
2. Explain different mechanisms of United Nations to ensure and protect the Human Rights
3. Comprehend the different Constitutional provisions and legislations to protect Human Rights in India
4. Analyze the functions of NHRC, Judiciary and PIL for protecting Human Rights in India
5. Examine the challenges to Human Rights of different vulnerable sections

Unit I: Human Rights

Meaning, Evolution and Importance, Approaches: Western, Marxian, Feminist and Third World

Unit II: UNO and Human Rights

Universal Declaration of Human Rights, International Covenants on Civil and Political Rights (ICCPR), International Covenant on Social Economic and Cultural Rights (ICSECR), The Office of the United Nations High Commissioners for Human Rights(UNHCHR)

Unit III: Human Rights in India

Constitutional Provisions- Fundamental Rights, Directive Principles of State Policy, Some important Legislations- 1) Protection of Civil Rights Act-1955, 2) Prevention of Atrocities (SC and ST) Act 1989, 3) Sexual Harassment of Women at workplace (Prevention, Prohibition and Redressal) Act, 2013, 4) The Rights of Persons with Disabilities Act-2016, 5) Right to information Act 2005. Agencies Protecting Human Rights; Judiciary, Public Interest Litigation, National Human Rights Commission and Media

Unit IV: Challenges to Human Rights

Human Rights Violations against Women, Children, Other marginalised sections like Minorities, Dalits, Adivasis and Women, Refugees

Reference Books:

1 Andrew Clapham, Human Rights: A Very Short Introduction, Oxford University Press, New York, 2007
2 Darren J O Byrne,(ed), Human Rights: An Introduction, Pearson, New Delhi,2004
3 Chiranjeevi Nirmal, Human Rights in India, Oxford University Press, New Delhi,1997.
4 Pavithran K S,(ed), Human Rights in India: Discourse and Contentions, Gyan books, NewDelhi,2018
5 Ujwal Kumar Singh, (ed), Human Rights and peace: Ideas, Laws, Institutions and Movements, Sage, New Delhi,2009

Field and Service Robots

411508(A)

Teaching scheme	Credit scheme	Examination Scheme
3 Hr/week	03	In-sem : 30 marks End-Sem : 70 Marks

Course Outcome:

The student will be able to

1. Define various applications of robot in health care and service tasks.
2. Analyze the function of sensors in the robot.
3. Design different application specific robots.

Unit 1: Introduction **(**7)

Service RT Systems, New Research Model and Field and Service Robotics, Robotics and RT Systems, From Robotics to RT Systems.

Unit 2: Drone Technology 7hr

Introduction, drone survey, UAV flight planning, Boundary setting and Data Collection by using Flight Mapping, Aerial Mapping using Drones, Topography Mapping Using Drones

Unit 3: Health Care and Service Tasks 7hr

Light Weight Autonomous Climbing Robot for Elderly and Disabled Persons' Services, Planning under Uncertainty for Reliable Health Care Robotics, Development of a Personal Service Robot with User-Friendly Interfaces, An Enhanced Robotic Library System for an Off-Site Shelving Facility.

Unit 4: Rescue and Agricultural Applications 7hr

Development of Pneumatically Controlled Expandable Arm for Search in the Environment with Tight Access, Development of Mobile Robots for Search and Rescue Operation Systems, Distributed Search and Rescue with Robot and Sensor Teams, Spraying Robot for Grape Production, Path Planning for Complete Coverage with Agricultural Machines

Unit 5: Helicopters and Air Vehicles 7hr

Experiments in Learning Helicopter Control from a Pilot, Landing on a Moving Target Using an Autonomous Helicopter, A Compact Millimeter Wave Radar Sensor for Unmanned Air Vehicles, Real-time Navigation, Guidance, and Control of a UAV Using Low-Cost Sensors.

Unit 6: Human-Robot Interaction 7hr

Towards Safer Roads by Integration of Road Scene Monitoring and Vehicle Control, Performing Skilled Work with an Interactively Operated Service Robot, Multi-purpose Eight-Legged Robot Developed for an Evaluation of a Neural Interface, Online Interactive Building of Presence.

References:

1. Field and Service Robotics Recent Advances in Reserch and Applications, ISBN-10 3-540-32801-7 Springer Berlin Heidelberg New York
2. New Trends in Medical and Service Robots Challenges and Solutions, ISBN 978-3-319-05431-5 (eBook) DOI 10.1007/978-3-319-05431-5

PLC and SCADA Programming
411509(A)

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures: 03 hours / week	Theory: 03	In-Sem: 30 Marks
		End-Sem: 70 Marks

Pre-requisites: Basic Electronics engineering, Basic Electrical engineering, Sensors technology

Course outcomes:

Student will be able to:

1. Identify the components of a Programmable Logic Controller system and understand their role.
2. Understand the basics of data conversion, Data Acquisition, Programmable Logic Controller and Supervisory Control and Data Acquisition.
3. Applying knowledge to interface input and output devices to Programmable Logic Controller
4. Apply knowledge to design logic circuits to perform industrial control functions and realize the same using ladder logic
5. Familiarization with Supervisory Control and Data Acquisition architecture and its applications
6. Familiarization with Human Machine Interface and Distributed Control Systems

Unit 1: Signal Conditioning and Data Acquisition System (DAS) (7)

Signal conditioning - Introduction, definition and need, block diagram and its elements, role of Digital to Analog Control and Analog to Digital Control, Isolator and concept of Signal Amplification.
Data Acquisition - Introduction, definition and need, concept of Analog DAS and Digital DAS, Single channel DAS and Multichannel DAS.

Unit 2: Programmable Logic Controller (7)

Introduction, Evolution of PLCs, Principles of operation, PLC Architecture and specifications, Classification, typical PLC specifications, construction and working of simple relay.
Description of PLC components - Power Supply, Analog & digital I/O modules, Programming Devices, CPU, I/O module specifications. Different Addressing modes, Selection criteria for PLC, common PLC Communication Protocols, Registers

Unit 3: PLC Programming (7)

Modes of Operation, concept of NO - NC switch, Coil, Timer, Counter, Latching, Interlocking and Program Scan Cycle. Rules for PLC Ladder Diagram Programming, memory mapping and Input/output addressing.
Types of programming languages used in PLCs - Ladder logic, Functional block diagram, Sequential flow chart, Instruction List, Structured Text.

Unit 4: Distributed Control Systems (DCS) (7)

Evolution of DCS, Structure of DCS, Importance of DCS in Process Automation, different Architecture of DCS, Features, Applications and Benefits of DCS. Networking Protocols - Field bus, Process bus, Modbus and Ethernet, CANopen, HART. Role of SCADA and DCS in industry 4.0

Unit 5: Supervisory Control and Data Acquisition System (SCADA) (7)

Introduction to supervisory control. Needs, Functions and Architecture of SCADA system. Components of SCADA: MTU, RTU, HMI. Role of SCADA in Thermal Power Stations, Petroleum Industries, Sugar Factories, Mass production industries, Traffic signals, Railways.
Introduction to Wireless SCADA.

Unit 6: Industrial Applications (7)

Interfacing of various inputs & outputs to PLC- Electromagnetic Control Relays, Contactors, manually operated switches, mechanically operated switches, Proximity sensors, Encoders, Decoders.
Logic Gate through Ladder, Latching operation, Design of tank liquid level control System, Sequential switching of motors, Motor interlocking, Temperature control, Conveyor belt control, Pneumatic Cylinder control.

Reference Books:

1. Frank D. Petreuzeulla, "Programmable Logic Controllers", Tata McGraw Hill publication, 6th Edition, 2023, ISBN10: 1264163347.
2. John R. Hackworth, "Programmable Logic Controllers: Programming Methods and Applications", Pearson, ISBN-10: 0130607185
3. Himanshu Kumar, "Advanced Industrial Automation: PLC programming in simplest way with 110 solved examples", Notion Press, ISBN-10: 1638320977
4. John W. Webb and Ronaldo A. Reis, "Programmable Logic Controllers: Principles and Applications, 5th Edition, 2015, Pearson Education India, ISBN-10: 9332555125
5. Rajesh Mehra, Vikrant Vij, "PLCs & SCADA Theory and Practice", 1st edition 2019, Laxmi Publications Private Limited, ISBN-10: 9381159114
6. W. Bolton, "Programmable Logic Controllers (English)", 5th Edition, Elsevier India ISBN: 9780750647465.

Elective V: Reverse Engineering
411510(A)

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures: 03 hours/week	Theory: 03	In-Sem: 30 Marks End-Sem: 70 Marks

---

Pre-requisites: Computer Aided Design, Electronics Engineering and Electrical Technology, Design of Machine Elements.

Course Outcomes: After learning this subject, the student will be able to:

1. Apply reverse engineering system to various applications.
2. Interpreting the terminologies related to re-engineering, forward engineering, and reverse engineering.
3. Disassemble products and specify the interactions between its subsystems and their functionality
4. Implement the Reverse Engineering methodologies.

Unit I: Introduction to Reverse Engineering (7)

What is Reverse Engineering, Use of Reverse Engineering, Reverse Engineering–The Generic Process, Scanning: Contact Scanners, Noncontact Scanners, Point Processing, and Application Geometric Model Development.

Unit II: Methodologies and Techniques for Reverse Engineering (7)

3-D Laser Scanners, Computer-aided Reverse Engineering, What Is Not Reverse Engineering, Computer-aided (Forward) Engineering, Computer-aided Reverse Engineering, Computer Vision and Reverse Engineering, Coordinate Measuring Machines, Active Illumination 3-D Stereo: Benefits and Drawbacks, Structured-light Range Imaging, Source Illumination Categories, sheet-of-light Range Imaging, Scanner Pipeline, Data Collection, Mesh Reconstruction, Surface Fitting.

Unit III: Reverse Engineering–Hardware and Software (7)

Introduction, Reverse Engineering Hardware, Contact Methods, Noncontact Methods, Destructive Method, Reverse Engineering Software, Reverse Engineering Software Classification, Reverse Engineering Phases, Fundamental Reverse Engineering Operations.

Unit IV: Selection of a Reverse Engineering System (7)

The Selection Process: Identify the Business Opportunity and Technical requirements, Vendor and System Information Gathering, Benchmarking, Point Capture Devices, contact Devices–Hard or Manual Probe, Touch-trigger Probe, Continuous Analogue Scanning Probe, Noncontact Devices, Triangulation, "Time-of-flight" or Ranging Systems, Structured-light and Stereoscopic Imaging Systems, Issues with Light-based

Approaches, Tracking Systems, Internal Measurement Systems, X-ray Tomography, Destructive Systems, Positioning the Probe, Post processing the Captured Data, Handling Data Points, Curve and Surface Creation, Inspection Applications, Manufacturing approaches.

Unit IV: Rapid prototyping for Reverse Engineering (7)

Modelling Cloud Data in Reverse Engineering, Data Processing for Rapid Prototyping, Integration of RE and RP for Layer-based Model Generation, The Adaptive Slicing Approach for Cloud Data Modelling, Planar Polygon Curve Construction for a Layer, Correlation Coefficient, Initial Point Determination, Constructing the First Line Segment (S1), constructing the Remaining Line Segments (Si, Determination of Adaptive Layer Thickness)

Unit VI: Applications of Reverse Engineering (7)

Applications of Reverse Engineering in Automotive Industries, Aerospace Industries, Medical Device Industries, Legal Aspects of Reverse Engineering, Barriers to Adopt Reverse Engineering

References:

1. K. Otto and K. Wood (2001) Product Design: Techniques in Reverse Engineering and New Product Development, Prentice Hall (ISBN 10: 0130212717 / ISBN 13: 9780130212719).
2. Raja and Fernandes (2008) Reverse Engineering: An Industrial Perspective, Springer-Verlag (ISBN: 978-1-84628-855-5).
3. Sokovic and Kopac (2006) RE as necessary phase by rapid product development, Journal of Materials Processing Technology, Elsevier (doi:10.1016/j.jmatprotec.2005.04.047).
4. Eldad Eilam (2005) Reversing: Secrets of Reverse Engineering, Wiley (ISBN: 0-7645-7481-7).
5. Robert W. Messler (2014) Reverse Engineering: Mechanisms, Structures, Systems & Materials, McGraw-Hill Education (ISBN: 9780071825160).

Elective V: Data Analytics

411510(A)

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures: 03 hours / week	Theory: 03	In-Sem: 30 Marks End-Sem: 70 Marks

---

Pre-requisites: Engineering Mathematics III

Course Outcomes:
After learning this subject, the student will be able to:

1. Effectively visualize and interpret the data
2. Apply predictive and prescriptive techniques for production engineering applications
3. Use data analysis for engineering applications through the powerful tools of data application

Unit 1: Introduction to data analytics [7]

Significance & applications of data analytics, Data collection, data processing, data transformation, data integration, data visualization, basic statistics, inferential statistics

Unit 2: Descriptive analytics [7]

Uni-variate/multi-variate statistics, bi-variate associations, correlations, covariance, analysis of variance (ANOVA)

Unit 3: Predictive analytics [7]

Multiple regression, conjoint analysis, neural networks, data clustering, Data mining

Unit 4: Classification techniques [7]

Linear classifiers, Quadratic classifiers, Support vector machines, Random forests.

Unit 5: Prescriptive analytics [7]

Decision tree analysis, Expert system, principal component analysis, genetic algorithms

Unit 6: Reinforcement learning [7]

Markov chain analysis, Monte Carlo simulation, Q learning, State action reward state action (SARSA) learning

References:

1. Acharya Seema and Chellappan, Big Data and Analytics, Willey India Pvt. Ltd. (2015), ISBN: 9788126554782
2. Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data, EMC Education Services, Willey India Pvt. Ltd. (2016), ISBN: 978-1-118-87622-0
3. Michael Minelli, Michale Chambers, Ambiga Dhiraj, Big Data Analytics: Emerging Business Intelligence and analytics trends for today‘s business, Willey India Pvt. Ltd. (2015)

Elective V: Entrepreneurship and Innovations

411510(A)

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures:03hours/week	Theory:03	In-Sem:30Marks End-Sem:70Marks

---

Pre-requisites: Industrial Engineering and Management, Production Management

Course outcomes:

After Successful completion of these course students will able to:

1. learn the various aspects of innovation and methods of fostering Innovation
2. Appreciate the importance of embarking on self-employment and has developed the confidence and personal skills for the same.
3. Start a small business enterprise by liaising with different stake holders
4. Effectively manage small business enterprise.

Unit I: Introduction to Innovation (7)

Creativity, Invention and innovation, Types of Innovation, Relevance of Technology for Innovation, The Indian innovations and opportunities, Promoting and managing innovation, Innovators and Imitators, Patents, Trademarks, Intellectual Property, Exploring, Executing, Leveraging and renewing innovation, Enhancing Innovation Potential & Formulating strategies for Innovation

Unit II: Strategy for Commercializing Innovation (7)

Innovation Process, Risks and barriers for introducing products and services, selecting a Strategy, setting up the Investment and establishing organisation, Evaluating the Costs and impact of the Project

UNIT III: Entrepreneurship (7)

Definition. Growth of industries in developing countries; role of industries in the national economy; characteristics; demand based and resources based ancillaries and sub-control types. Government policies, stages in starting an industry, types (family business/start-ups etc.), Sources of finance.

UNIT IV: Project identification and accountancy (7)

Assessment of viability, formulation, evaluation, financing, field-study and collection of information, preparation of project report, demand analysis, material balance and output methods,

Accountancy: Preparation of balance sheets and assessment of economic viability, decision making, expected costs, planning and production control, preparation of financial reports, accounts and stores studies.

UNIT V: Project Planning and control (7)

The financial functions cost of capital approach in project planning and control. Economic evaluation, risk analysis, capital expenditures, policies and practices in public enterprises. Profit planning and programming, planning cash flow, capital expenditure and operations. Control of financial flows, control and communication.

UNIT VI: Laws (7)

Laws concerning entrepreneur viz, partnership laws, business ownership, sales and income taxes and workman compensation act. Role of various national and state agencies which render assistance to small scale industries.

References:

1. Robin Lowe and Sue Marriott, Enterprise: Entrepreneurship and Innovation Concepts, Contexts and Commercialization, ISBN: 978-0-7506-6920-7
2. Khanka. S.S., ―Entrepreneurial Developmen, S.Chand & Co. Ltd.,Ram Nagar, New Delhi, 2013. ISBN: 978-81-219-1801-5
3. Donald F Kuratko, ― Entreprenuership – Theory, Process and Practice‖, 9th Edition, Cengage Learning 2014. ISBN:9781305576247, 1305576241
4. Rabindra N. Kanungo "Entrepreneurship and innovation", Sage Publications, New Delhi, 1998. ISBN:9780761992844, 0761992847
5. Peter F. Drucker, Innovation and Entrepreneurship, ISBN:9780750685085, 0750685085
6. John Forbat, "Entrepreneurship: The Seeds of Success", Harriman House, 2007, ISBN: 1905641257; 9781905641253.
7. Veerbhadrappa Havinal, "Management and Entrepreneurship", 2009, New Age International, ISBN:9788122426021, 8122426026
8. Joseph, L. Massod, Essential of Management", Prentice Hall of India.

Elective V: Electronic System Design and Analysis

411510 (A)

Teaching Scheme	Credit Scheme	Examination
Lectures: 03 Hours/week	Theory: 03	In-sem: 30 Marks End-sem: 70 Marks

Prerequisites: Basics of electronics engineering

The course should enable the students to:

1. Verify and reflect over and provide critical assessment of a concrete implementation of their own design.
2. Analyse electronic systems in terms of safety**,** Reliability and thermal management
3. Design systems with reference to protection, electromagnetic compatibility.
4. Implement and test self-designed electronic systems.

Unit 1: Design Process and Its Fundamentals (7)

Life Cycle of Electronic Products, Design and Development Process: Guidance for Product Planning, Design and Development, Planning Development Work, Information Flow, Feasibility Study During Product Planning, Task Definition and Conceptual Stage, Functional Specification Scheduling. Technical Drawings. Circuit Diagrams .Computer-Aided Design (CAD)

Unit 2: System Architecture and Safety Requirements (7)

Introduction—Terminology, Functions and Structures, System Characteristics of Devices, System Environment, System Functions, System Structure. System Design Architecture, Electronic System Levels, System Protection CE Designation, Protection Classes, IP Codes of Enclosures

Unit 3: Reliability Analysis (7)

Introduction .Calculation Principles. Probability Terminology, Reliability Parameters, Exponential Distribution, Failure of Electronic Components, Failure of Electronic Systems, Serial and Parallel Systems, Reliability Analysis of Electronic Systems, Electronic Systems with Redundancy—Parallel Systems Service and Maintenance of Electronic Systems. Recommendations for Improving Reliability of Electronic Systems.

Unit 4: Thermal Management and Cooling (7)

Introduction, Temperatures, and Power Dissipation, Heat Transfer, Application Examples in Electronic Systems, Heat Dissipation from Open Enclosures, Heat Dissipation from Sealed Enclosures, Heat Transfer through Enclosure Panels, Interior Air Temperature, Heat Transfer inside an Open Enclosure, Heat Transfer inside a Sealed Enclosure, Forced Convection with Fans and Fan Selection, Recommendations for Thermal Management of Electronic Systems

Unit 5: Electromagnetic Compatibility (EMC) (7)

Introduction: Coupling Between System Components: Conductive Coupling Capacitive Coupling Inductive Coupling, Electromagnetic Coupling, Grounding Electronic Systems, Description of Reference

Grounds, Reference Systems Schemes (Grounding Systems) , Return Conductor to the Reference Point for Digital Signals, Return Conductor to the Reference Point for Analog, Signals Ground Loops. Shielding from Fields. Electrostatic Discharge (ESD). Recommendations for EMC-Compliant Systems Design

Unit 6: Recycling Requirements and Design for Environmental (7)

Introduction, Manufacture, Use, and Disposal of Electronic Systems in the Circular Economy. Product Recycling in the Disposal Process, Design and Development for Disassembly, Material Suitability in Design and Development. Recommendations for Environmentally Compliant Systems

References:

1. Jens Lienig, Hans Bruemmer, "Fundamentals of Electronic Systems Design", Springer; 1st ed. 2017 edition (4 May 2017) ISBN-13 : 978-3319558394
2. Jürgen Gausemeier, Franz Josef Rammig, Wilhelm Schäfer "Design Methodology for Intelligent Technical Systems" Lecture Notes in Mechanical Engineering, Springer.

Elective VI: Additive Manufacturing

411511(A)

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures: 03 hours / week	Theory: 03	In-Sem: 30 Marks End-Sem: 70 Marks

---

Pre-requisites: Manufacturing processes, Engineering metallurgy, Solid mechanics

Course outcomes:

Student will be able to:

- Grasp the principle, methods, possibilities and limitations as well as environmental hazards of Additive Manufacturing technologies.
- Identify the characteristics of the different materials used in Additive Manufacturing technologies.
- Explore the potential of additive manufacturing technologies in real life applications.

Unit I: Additive Manufacturing (AM) Overview (7)

Introduction to AM, Historical Development, Additive v/s Conventional Manufacturing, Role of AM in Product development cycle, Rapid prototyping, Relevance of AM in Industry 4.0, Current industry and manufacturing trends driving AM, AM Process-Chain, Reverse engineering, Advantages, Types of materials, Classification of AM Processes (Process-based, material form based, application-based - direct and indirect processes and Micro- and Nano-additive processes), Process Planning for Additive Manufacturing.

Unit II: Light and LASER based Techniques (7)

Introduction, Process and mechanism, Materials, Process Physics, Parameters, Benefits, Drawbacks, Limitations and Applications

Light-Based Photo-curing: Stereolithography (SLA), Digital Light Processing (DLP), Direct Laser Writing (DLW), Continuous Liquid Interface Production (CLIP)

Laser-Based Melting: Selective Laser Sintering (SLS), Direct Metal Laser Sintering (DMLS), Selective Laser Melting (SLM), Electron-Beam Melting (EBM), Laser Blown Powder, Laser Wire Deposition, Laser Engineered Net Shaping (LENS), 3D Laser Cladding.

Unit III: Extrusion and energy based Techniques (7)

Introduction, Process and mechanism, Materials, Process Physics, Parameters, Benefits, Drawbacks, Limitations and Applications

Extrusion-Based Deposition: Fused Deposition Modeling (FDM), Fused Filament Fabrication (FFF), Direct Ink Writing (DIW), Robocasting, Bio-printing

Inkjet(droplet)-Based Deposition and Fusion: Multi-jet Modeling (MJM), Polyjet Printing, Nanoparticle Jetting, Binder Jetting, Multi-Jet Fusion, Color-jet Printing (CJP), Energy Deposition Techniques: Plasma/TIG/MIG/Arc Deposition, Electron Beam-based DED, Direct Metal Deposition (DMD).

Unit IV: Materials and Design for AM (7)

Introduction, Materials: Metals, Polymers, Ceramics & Bio-ceramics, Composites, Hierarchical Materials, Biomimetic Materials, Shape-Memory Alloys, 4D Printing & Bio-active materials, Material selection,

AM Material Specific Process Parameters: Processes, Heat or Chemical Treatments, Phase Transformations, Process Selection for various applications, DfAM: Process specific strategies, Rules and Recommendations,

Quality considerations and Post-Processing techniques: Requirements and Techniques, Support Removal, Sanding, Acetone treatment, Polishing, Heat treatments, Hot isostatic pressing, Materials science, Surface enhancement Techniques and its Material Science Analysis of AM's error sources.

Unit V: Hardware and Software for AM (7)

Construction of Basic AM Machines: Equipment Layout and sub-system Design, Construction, Working, Equipment Topology/Layout Frame Designs, 3D Printer Design Considerations (Filament, Frame, Build Platform, Extruder Design, Nozzles, Print Bed, Heated build/Base Plate, Heater, Dispenser, Optical system, Cooling system, Gas Recirculation System, Laser controller, Gas Filtration, Inert Gas Cooling system, Powder Handling System, Loading/unloading System.

Software and Controller: Types of In-fill, Types of slicing, Software Integration (with Process, Slicing, etc), Control system (PLC and safety PLC, micro control/ Microcontroller, Micro-processor control), CAD Software and Controller Interfacing, CURA Software, Relevant G/M Codes, Standard firmware (Merlin Software, etc), In-process Monitoring, Calibration.

Unit VI: Case Studies, Application and Special Topics (7)

Case Studies and Application of AM: 3D printing in prominent industries (Aerospace, Electronics, Defense, Automotive, Construction, Architectural, Machine-Tools), Other industrial applications (Health-Care, Personalized Surgery, Bio-medical Applications, Assistive Devices, Food-Processing, Food & Consumer Applications, Art, Fashion, Jewelry, Toys & Other Applications, etc)

Special Topics: 4D/5D Printing, Bio-printing, Bio-materials, scaffolds and tissue and Organ Engineering, Mass Customization and Future trends.

Reference Books:

1. L. Lu, J. Y. H. Fuh and Y.S. Wong, "Laser-Induced Materials and Processes for Rapid Prototyping", Springer, 2001
2. Andreas Gebhardt and Jan-Steffen Hötter, "Additive Manufacturing: 3D Printing for Prototyping and Manufacturing" Hanser Publishers, Munich, 2016.
3. Ben Redwood, FilemonSchöffer& Brian Garret, "The 3D Printing Handbook: Technologies, design and applications", 3D Hubs B.V. 2017
4. Ehsan Toyserkani, Amir Khajepour, Stephen F. Corbin, "Laser Cladding", CRC Press, 2004
5. Andreas Gebhardt, "Understanding Additive", Hanser Publishers, Munich, 2011
6. Ben Redwood, Filemon Schöffer & Brian Garret, "The 3D Printing Handbook – Technologies, Design and Applications" Part One:3D Printing Technologies and Materials, 3D Hubs, 2017
7. Chee Kai, Kah Fai, Chu Sing, 'Rapid Prototyping: Principles and Applications", 2nd Ed., 2003

8. D. T. Pham and S.S. Dimov, “Rapid Manufacturing” Springer, 2001
9. Rupinder Singh J. Paulo Davim, “Additive Manufacturing - Applications and Innovations” CRC Press Taylor& Francis Group, 2019
10. I. Gibson, D. W. Rosen, B. Stucker, “Additive Manufacturing Technologies” Springer, 2010
11. L. Jyothish Kumar, Pulak M. Pandey, David Ian Wimpenny, “3D Printing and Additive Manufacturing Technologies” Springer, 2019

Elective-VI: Industry 4.0

411511(A)

Teaching Scheme	**Credit Scheme**	**Examination Scheme**
Lectures: 03 hours / week	Theory: 03	In-Sem: 30 Marks End-Sem: 70 Marks

---

Pre-requisites: Industrial Engineering, Sensor Technology

Course outcomes:

Student will be able to:

1. Conceptualize the basic idea in industry 4.0.
2. Design industrial 4.0 systems for various application.
3. Analyze of industry 4.0 systems for energy and smart vehicular applications.
4. Integrate the different cyber physical system with industry 4.0

Unit 1: Introduction to Industry 4.0 **(7)**

Introduction, Historical Context, General framework, Application areas, Dissemination of Industry 4.0 and the disciplines that contribute to its development, Artificial intelligence, The Internet of Things and Industrial Internet of Things, Additive manufacturing, Robotization and automation, Current situation of Industry 4.0, Introduction to Industry 5.0

Unit 2: Smart Systems and Smart Grid **(7)**

Smart Manufacturing, Smart, Devices and Products, Smart Logistics, Smart Cities, Predictive Analytics, Smart grid definition and development Smart Grid, Understanding the Smart Grid, Smart grid solutions, Design challenges of smart grid in Industry 4.0.

Unit 3: Digital Twin **(7)**

Introduction to digital twin, Applications, Opportunities and challenges influencing digital twin, Introduction to the impact of the digital twin, Cyber-physical systems, Process automation and optimization, Predictive maintenance and anomaly detection on the manufacturing ecosystem and its application.

Unit 4: Cloud Computing **(7)**

Introduction to cloud computing, virtualization, Cloud deployment techniques, Architecture of cloud application, cloud programming, adoption and use of cloud, role of cloud computing in IoT and Industry 4.0, concept of Fog computing.

Unit 5: Cyber Security **(7)**

Introduction to cyber security, Cyber defence, Cyber ethics, Cyber law and cyber policy, Data communications & networking, Digital forensics, Information Technology, Security systems

Unit 6: Applications and Case Studies **(7)**

Artificial Intelligence, Industry practices in AI, Industry 4.0 laboratories, IoT, IIoT Case studies on IoT and IIoT.

References:

1) Alasdair Gilchrist “Industry 4.0: The Industrial Internet of Things”, A press , ISBN 978-1-4842-2046-7
2) Pengwei Du and Ning Lu, “Energy storage for smart grids: planning and operation for renewable and variable energy resources VERs”, Academic Press, Reprint edition, ISBN-13:978-0128100714
3) Hossam A. Gabbar, “Smart Energy Grid Engineering”, Academic Press, ISBN:978- 0-12-805343-0
4) Miller M, “The internet of things: How smart TVs, smart cars, smart homes, and smart cities are changing the world”, Pearson Education, ISBN: 9780134021300
5) Hossam A. Gabbar, “Smart Energy Grid Engineering”, Academic Press, ISBN 978-0-12-805343-0
6) Mini S. Thomas, John Douglas McDonald, ”Power System SCADA and Smart Grids”, CRC Press, ISBN: 9781482226751
7) Sabina Jeschke, Christian Brecher, Houbing Song, Danda B. Rawat , “Industrial Internet of Things: Cyber manufacturing Systems, Springer Publication, ISBN- 978-3-319-42559-7

Elective VI: VLSI Design for Robotics

411511(A)

Teaching Scheme	Credit	Examination Scheme
Theory: 03 Hrs. / Week	Theory: 03	In-Sem: 30 Marks
		End Sem: 70 Marks

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

1. Develop effective HDL codes for digital design.
2. Apply knowledge of real time issues in digital design.
3. Model digital circuit with HDL, simulate, synthesis and prototype in PLDs.
4. Design CMOS circuits for specified applications.
5. Analyze various issues and constraints in design of an ASIC.

Course Contents

Unit I Design with HDL (7)

Design Flow, Language constructs, Data objects, Data types, Entity, Architecture & types of modelling, Sequential statements, Concurrent statements, Packages, Sub programs, Attributes, HDL modelling of Combinational, Sequential circuits and FSM. Simulations, Synthesis, Efficient coding styles, Hierarchical and flat designs, Partitioning for synthesis, Pipelining, Resource sharing.

Unit II Digital Design and Issues (7)

Sequential synchronous machine design, Moore and Mealy machines, HDL code for Machines, FIFO. Meta-stability and solutions. Noise margin, Fan-out, Skew, Timing considerations, Hazards, Clock distribution, Clock jitter, Supply and ground bounce, Power distribution techniques, Power optimization. Interconnect routing techniques, Wire parasitic, Signal integrity issues. I/O architecture.

Unit III PLD Architectures and Applications 7 Hrs.

Design Flow. CPLD Architecture, Features, Specifications, Applications. FPGA Architecture, Features, Specifications, Applications. Clock management techniques. The Simulation and Synthesis Tools, FPGA synthesis and implementation. Comparison of CPLD & FPGA.

Unit IV Digital CMOS Circuits 7 Hrs.

N-MOS, P-MOS and CMOS. MOSFET parasitic, Technology scaling, Channel length modulation, Hot electron effect, Velocity saturation. CMOS Inverter, Device sizing, CMOS combinational logic design, Power dissipations, Power delay product, Body Effect, Rise and fall times, Latch Up effect, Transmission gates.

Unit V Application Specific Integrated Circuits 7 Hrs

Design Flow, Cell design specifications, Spice simulation, AC and DC analysis, Transfer Characteristics, Transient responses, Noise analysis, Lambda rules, Design Rule Check, Fabrication methods of circuit

elements, Layout of cell, Library cell designing for NAND & NOR, Circuit Extraction, Electrical Rule Check, Layout Vs. Schematic, Post-layout Simulation and Parasitic extraction, Design Issues like Antenna effect, Electro migration effect, Cross talk and Drain punch through, Timing analysis.

Unit VI VLSI Testing and Analysis 7 Hrs.

Types of fault, Need of Design for Testability (DFT), DFT Guideline, Testability, Fault models, Path sensitizing, Test pattern generation, Sequential circuit test, Built In Self Test, JTAG & Boundary scan, TAP Controller.

References:

1. Charles H. Roth, "Digital Systems Design using VHDL", 2 nd Edition, Thompson Learning
2. 2. Wyane Wolf, "Modern VLSI Design (IP-Based Design)", 4th Edition, Prentice Hall.
3. 3. Steve Kilts, "Advanced FPGA Design Architecture, Implementation and Optimization" Wiley Interscience.
4. 4. E. Weste, David Money Harris, "CMOS VLSI Design: A Circuit & System Perspective", 4 th Edition, Pearson Publication.
5. R. Jacob Baker, "CMOS Circuit Design, Layout, and Simulation", 3rd Edition, Wiley-IEEE Press.
6. John F. Wakerly, "Digital Design Principles and Practices", 3rd Edition, Prentice Hall.
7. M. Morris Mano , "Digital Design", 3rd Edition , Pearson.
8. Cem Unsalan, Bora Tar, "Digital System Design with FPGA: Implementation Using Verilog and VHDL", McGraw-Hill.

MOOC / NPTEL Courses:

1. NPTEL Course on "VLSI Technology", By Dr. Nandita Dasgupta, IIT Madras Link: https://nptel.ac.in/courses/117106093
2. NPTEL Course on "VLSI Circuits", By Prof. S.Srinivasan, IIT Madras Link: https://nptel.ac.in/courses/117106092

Elective VI: Intelligent Robotics Systems

411511(A)

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures: 03 hours / week	Theory: 03	In-Sem: 30 Marks End-Sem: 70 Marks

---

Pre-requisites: Artificial Intelligence in Robotics, Micro-Electro mechanical Systems

Course Outcomes:

1. Describe the concept of robot cognition and perception
2. Analyze the various path planning techniques by briefing about the robot's environment and explaining about the programs used
3. Develop knowledge about simultaneous localization and mapping based techniques and paradigms.
4. Analyze the performance of mobile robots controlled through the web
5. Evaluate the performance of collaborative robots

Course contents:

Unit 1: Cognitive Robotics **(7)**

Randomized path planning: Visibility Graphs, Voronoi diagrams, Potential Fields and Cell Decomposition, Planning with moving obstacles, Probabilistic Roadmaps, Simultaneous Localization and Mapping (SLAM): Problem Definition, Mathematical Basis, Examples, Extended Kalman filter, Graph-Based Optimization Techniques

Unit 2: Swarm robotics **(7)**

Introduction, Swarm Robot Hardware, Modeling Swarm Systems and Formal Design Methods, Models for Collective Decision-Making Processes, Adaptive Aggregation

Unit 3: Microrobotics **(7)**

Micro-robotic actuators, Micro-robotics devices: Micro-grippers and other micro-tools - Micro conveyors - Walking MEMS Micro-robots – Multi-robot system: Micro-robot powering, Micro-robot communication.

Unit 4: Nuero robotics **(7)**

Optic flow in robots, Visually guided behaviour in robots, vertebrate motor control, cerebral models in robotics, recognition of hand actions, imitating robots, speech recognition.

Unit 5: Cloud Robotics **(7)**

Properties of Networked Telerobotics – Building a Networked Telerobotic system – State command Presentation – Command Execution/ State Generation – Collaborative Control. Introduction to networked

robot system on the Web – Software Arch itecture and design – Interface design. Autonomous Mobile Robot on the Web

Unit 6: Collaborative robotics (7)

Robots to Cobots, force limited robots, collaborative work cells, collaborative safety, design and deployment of Cobots. Applications of Cobots.

References:

1. Patnaik, Srikanta, "Robot Cognition and Navigation - An Experiment with Mobile Robots", SpringerVerlag Berlin and Heidelberg, 2007.
2. Howie Choset, Kevin LynchSeth Hutchinson, George Kantor, Wolfram Burgard, Lydia Kavraki, and Sebastian Thrun, "Principles of Robot Motion-Theory, Algorithms, and Implementation", MIT Press, Cambridge, 2005
3. HoomanSomani,"Cognitive Robotics", CRC Press, 2015
4. AnisKoubaa, ElhadiShakshuki, "Robots and Sensor Clouds", Springer, 2015.
5. . Joao Pedro, Carvalho Rosa, "Cloud Robotics – Distributed Robotics using Cloud Computing", Coimbra, 2016.
6. Vito Trianni "Evolutionary Swarm Robotics", Springer, 2008

Field and Service Robots Lab

411508(B)

Teaching scheme	Credit scheme	Examination Scheme
2Hr/week	Practical: 01	TW: 25 Marks Oral : 50 marks

Oral will be based on following topics:

1. Applications of drones for surveillance and delivery purpose.
2. Topology mapping and aerial mapping with drones.
3. Application of robots in health care and medical sectors
4. Any one applications on agricultural robotics.
5. Case study on rescue systems and human threatening.
6. Field visit

PLC and SCADA Programming Lab

411509 (B)

Teaching Scheme	**Credit Scheme**	**Examination/Marking Scheme**
Practical: 02 hours / week	Practical: 01	TW: 25 Marks
		Oral: 50 Marks

Exp. No. 01	Familiarization of PLC environment and establishing connections
Exp. No. 02	Develop and test logic using PLC Ladder for; • AND, OR and Latching operation • Simple ladder logic program using timers • Simple ladder logic program using counters
Exp. No. 03	PLC programming for Electro-pneumatic system
Exp. No. 04	PLC programming for Electro-hydraulic system
Exp. No. 05	PLC programming for robotics and electro-mechanical system
Exp. No. 06	Develop process control application using SCADA
Exp. No. 07	Collect and analyze Industrial Control System (ICS) Cyber Attack Datasets
Exp. No. 08	Interface SCADA with PLC for given application
Exp. No 09	Design of digital system in virtual simulation using SCADA
Exp. No. 10	Designing a virtual HMI panel

Project Stage 2
411512

Teaching Scheme	Credit Scheme	Examination Scheme
Project: 12 hours / week	Practical: 06	TW: 100 Marks PR: 50 Marks

As per submitted project phase II plan to complete it within the time schedule, the term work shall consist of:

Fabrication of models, machines, prototypes based on new ideas, robots and machine based on hi-tech systems and automation, experimental set-up, fabrication of testing equipment, renovation of machines, etc. Above work shall be taken up individually or in groups.

OR

Extensive analysis of some problems done with the help of a computer individually or in a group not exceeding two students.

A detailed report on the work done shall include project specification, design procedure, drawings, process sheets, assembly procedure and test results etc. Project may be of the following types:

(i) Manufacturing / Fabrication of a prototype machine' including selection, concept, design, material, manufacturing the components, assembly of components, testing and performance evaluation
(ii) Improvement of existing machine / equipment / process.
(iii) Design and fabrication of robots for specialized applications,
(iv) Computer aided design, analysis of components such as stress analysis.
(v) Problems related to Automated Storage and retrieval system
(vi) Design of a test rig for performance evaluation of machine devices.
(vii) Design and development. of non-standard robots
(viii) Analysis, evaluation and experimental verification of any engineering problem
(ix) Design and development of service robots
(x) Hardware system development to ingrate robotics operations
(xi) Low cost automation, Computer Aided Automation in Manufacturing.
(xii) Development of prototypes for new concepts in robotics such as biological robots, swarm robotics, drones, humanoids
(xiii) Development of artificial intelligence systems for humanoids and robots

OR

Computer based design / analysis or modelling / simulation of robot(s), mechanism(s) or system (s) and its validation or comparison with available benchmarks / results.

Two copies of Final Project Report shall be submitted to the college. The students shall present their Final Project Phase-II report. Before the examiners. The oral examination, shall be based on the term work

submitted and jointly conducted by an internal and external examiner from industry, at the end of second semester.

Format of the project report should be as follows:

Paper: The Project report should be typed/printed on white paper of A-4 size.

Typing: The typing shall be with one and half spacing and on one side of the paper.

Binding: The Industrial Implant Report should be submitted with front and back cover in black Hard bound, with golden embossing.

Margins: Left -1.25", Right -1". Top and Bottom 1"

Sequence of Pages:

- Title page
- Certificate form Institute
- Completion Certificate form Industry, if sponsored.
- Acknowledgement
- Abstract
- Index
- Nomenclature and Symbols
- Actual Content
- Conclusion
- References.

Front cover: The front cover shall have the following details in block capitals

Title at the top.

Name of the candidate in the centre, and

Name of the Institute, Name of Industry, if sponsored and the year of submission on separate lines, at the bottom.

Blank sheets: No blank sheets be left anywhere in the report.

Audit Course 8: Leadership Excellence

411513

Course contents:

Unit I: Team working and collaborations:

Understanding team and team dynamics, leading teams, analysing teams and team performance, collaborative team. Characteristics of Successful Team, Stages in team Development, Team Structure, Team leadership, Assessing effective team, Cross functional Collaboration: Introduction, definition cross functional team work, Why use cross functional teams, Desired outcomes and team types, Towards a model of cross functional team type

Unit II: Meeting and Email Etiquettes:

Managing a Meeting: Meeting agenda, Meeting logistics, Minute taking, protocols during the meeting; Duties of the chairperson, Ground rules for conducting meeting; *Effective Meeting Strategies:* Preparing for the meeting, Conducting the meeting, Evaluating the meeting, Rules for meetings, Codes of Conduct while attending Meetings, Tips for good meeting etiquette;

Business Card Etiquette: Carrying business cards, exchanging business cards, Receiving and storing business cards;

E-Mail Etiquette: Significance of Netiquette, Enforcement of email etiquettes in the organization, E-mail: Way of professional communication, Basic Email Etiquettes: Proper Grammar, Spelling, Punctuation, Styling and Formatting, Body of Email, Response, Privacy; Contents of email, Best practices of writing emails, Controlling contents of email

Unit III: Time Management

Time Management strategies: Daily planning, Prioritization of Tasks, Use of Time Management Tools, Determination of productive Times, Remove Distractions, Use of a Timer, Splitting Large Projects into Pieces, Delegation of Work;

Time management tools: **Time tracking software,** To-Do-list, project management software, communication tools (skype, slack, zoom), Apps helpful in creating good habits, Managing interruptions, managing procrastination;

Time management skills: Prioritizing, Delegation, Decision-making, Goal setting, Multitasking, Problem solving, Strategic thinking, Scheduling.

References:

1. Ayers, Janet. "Leadership Development: Changes, Challenges, and Opportunities." In: Proceedings of the Southern Leadership Conference. University of Puerto Rico, San Juan. April 1996.
2. Hesselbein, Frances, Marshall Goldsmith, Richard Beckhard (eds.). The Leader of the Future. San Francisco: Jossey–Bass Publishers, 1996
3. Covey, Stephen. The 7 Habits of Highly Effective People. Simon & Schuster. 1990.